

Figure 3E. Locations of floodplain forest, high floodplain oak forests, and riverscours prairies within the lower central section of the park boundary.

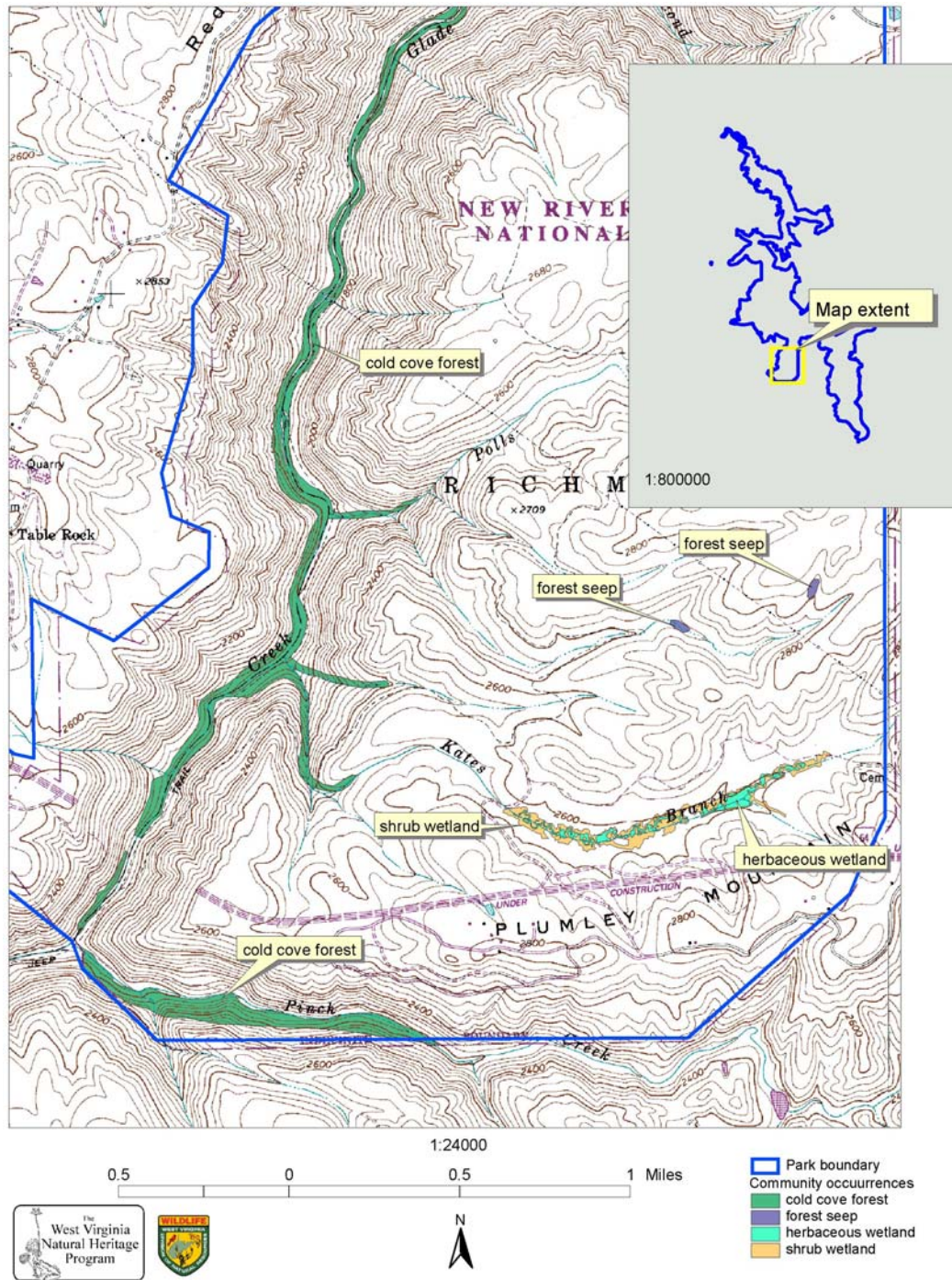
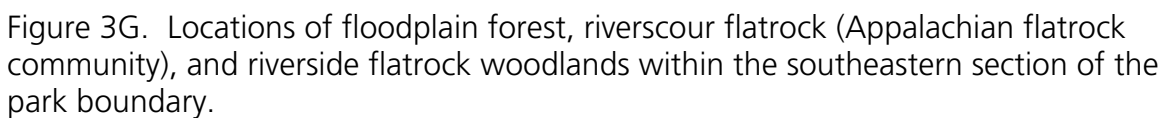


Figure 3F. Locations of cold cove forests, forest seeps, herbaceous wetland, and shrub wetland within the southwestern section of the park boundary.



railroads, residences, and roads. Distinctive communities in the northern portion of the park include cliff faces and rimrock pine (Figure 3). Distinctive communities of the southern portion of the park include large wetlands like those associated with Kates Branch.

Pauley et al. (1997) examined vascular flora associated with proposed development sites in NERI. Rouse and McDonald (1986) conducted a rare vascular plant survey for NERI. They provided a complete list of rare species found within NERI along with habitat requirements, distribution, and management recommendations for each species (Rouse and McDonald 1986).

Norris (2002) comprised a plant species list for NERI that includes species of plants likely to occur in the park but not yet documented. He determined that approximately 74% of the plant species at NERI have been documented. A goal of park managers is to document 90% of plant species for the park. In order to achieve this goal, researchers will have to begin scouting wide areas for the express purpose of creating a complete floristic list (Norris 2002). These floristic lists should be accompanied by vouchered specimens or photographs with locality and surrounding habitat described (Norris 2002).

### Unfragmented Forest

**Current Status and Significance:** The expanse of mixed-mesophytic forest in which NERI is located is the largest remaining area of midlatitude forest in the world, making it a globally significant resource (Ritters et al. 2000). This continuous span of mixed-deciduous forest (comprised of both oak-hickory and mixed-mesophytic forest types) in NERI is approximately 96.6 km (60 mi) long by 3.2 km (2 mi) wide, one of largest in the nation (Ritters et al. 2000). In NERI, approximately 84% of the land cover is forested and 65% of the forestland is classified as interior forest based on categories described by Ritters et al. (2000). For comparison, statewide, only 45% of the forestland would be classified as interior forest based on the same scale of analysis (WV Gap Analysis Program 2003).

Vanderhorst (2003) performed a GIS analysis in order to identify large, unfragmented forest blocks that contain a diversity of vegetation communities in NERI. These selected blocks represent large, intact natural landscapes that could be targeted for conservation in NERI (Figure 4). To select these blocks, Vanderhorst (2003) mapped roads and rail lines to locate blocks of at least 40.5 ha (100 ac) in size that did not contain roads or rail lines within the park. He chose 40.5 ha as the minimum size of blocks because a forest block must be at least 100 acres (preferably 250 ac [100 ha]) in size to support a community of forest-interior birds (Robbins et al. 1989). Forest blocks smaller in size will only support forest-edge species (Robbins et al. 1989).

After identifying all blocks  $\geq 40.5$  ha (100 ac), he then considered other fragmenting features, such as utility corridors, stripmines, and landownership in the analysis. Finally, a spatial analysis of elevation and Ecological Land Units (ELUs, a concatenation of geology, elevation, and landform values) was conducted to calculate elevation range and ecological diversity for each block.

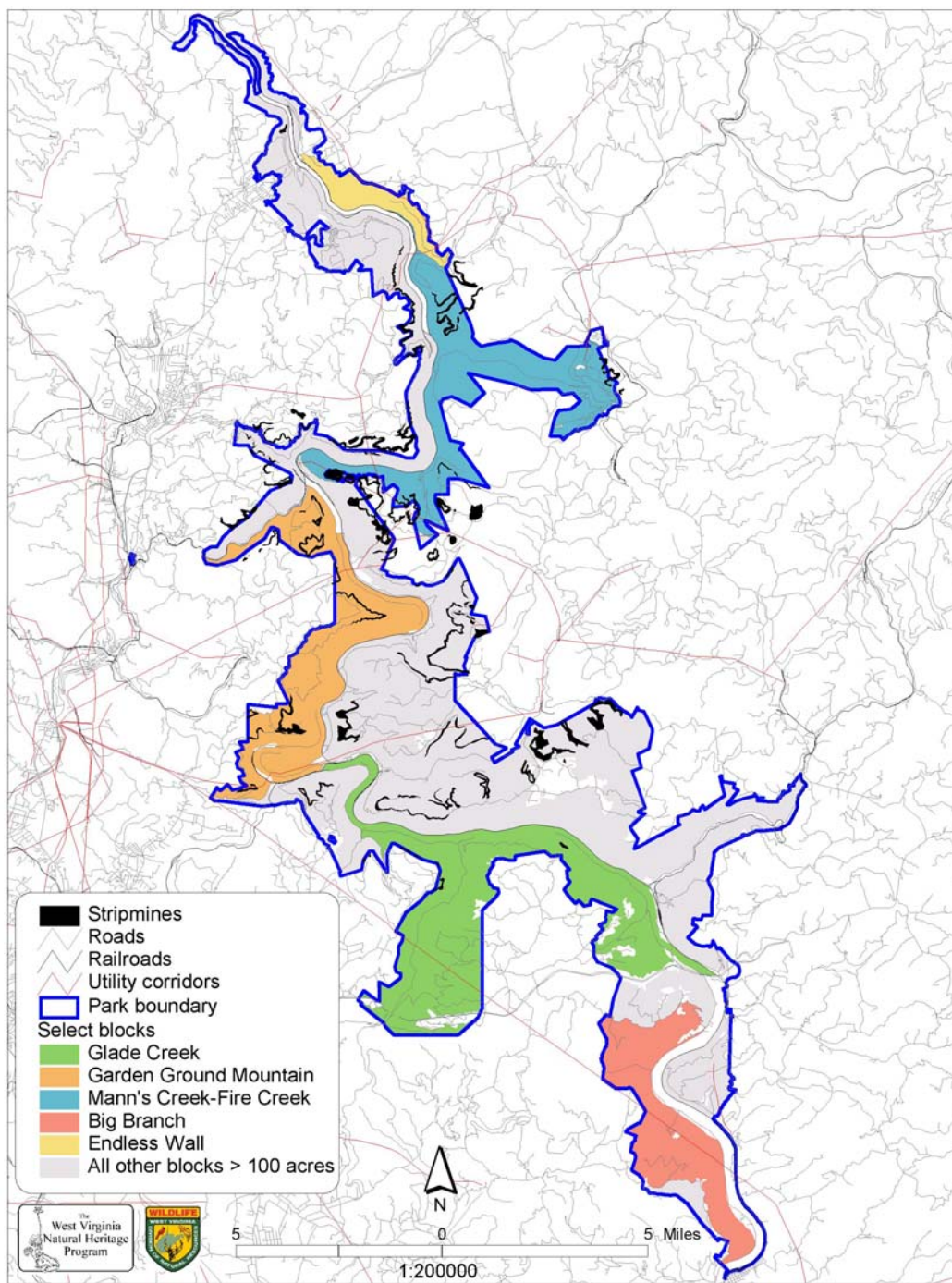


Figure 4. Selected blocks for conservation in New River Gorge National River.

According to the analysis, about 91% of the area within the park's boundary is contained within blocks greater than 40.5 ha (100 ac). About 83% is contained within blocks greater than 404.7 ha (1,000 ac). About 45% is contained within the four largest blocks that are each greater than 2,023.4 ha (5,000 ac) (Vanderhorst 2003).

Vanderhorst (2003) developed a portfolio of blocks representing ecological diversity and geographic range of the park. Positive factors for ranking and incorporation in the portfolio included block size, rail-less/roadless reaches of riverside, presence of tributary drainages, ecological diversity (variety of ELUs, geology, aspect, elevational range, and presence of rare or exemplary natural communities), and proximity of additional adjacent roadless area outside the park boundaries. Rare or exemplary communities included in this analysis were hemlock forests, Virginia pine forest, forest seeps, cliff communities, Appalachian flatrock community, cold cove forest, pitch pine woodland, riverscours prairie, backwater slough, high floodplain oak forest, floodplain forest, and shrub and herbaceous wetlands (Figure 3). Negative ranking factors included areas of stripmines and long lengths of roads, length of utility corridors, and length of block perimeter. Using this ranking approach, five blocks were chosen and mapped that represent a large part of the ecological diversity and geographical range of the park (Figure 4). Designation of these five blocks should not, however, infer a lesser value of any other roadless and/or rail-less blocks in the park.

The five selected blocks were Glade Creek, Garden Ground Mountain, Mann's Creek-Fire Creek, Big Branch, and Endless Wall (Figure 4). The individual blocks are described below:

- Glade Creek (4,115 ha [10,170 ac]) is the largest forest block at NERI identified by the GIS analysis. The area extends from the railroad on river right across the river up to the plateau top and includes a large proportion of the Glade Creek drainage. The block includes a long roadless stretch of riverside on river left from Glade Creek upstream to Farley Creek. This block includes one of the most extensive areas of plateau top within the park boundary. Rare communities include riverscours prairie and high floodplain oak forest along the river, cold cove forest along Glade Creek, and herbaceous wetlands, shrub wetlands, and forest seeps on the plateau around Kates Branch. There are few stripmines, and most roads are abandoned or restricted to pedestrian travel. The Glade Creek Road is currently closed due to landslides but is likely to be reopened and maintained for recreational and administrative use. If adjacent roadless areas outside the park boundaries are added, the size of this block is more than doubled, increasing its conservation value.
- Garden Ground Mountain (2,822 ha [6,973 ac]) forest block extends from the railroad on river right across the river and up to the plateau top. The most exceptional features of this area are the extensive floodplain forests and roadless stretches of riverside on river left. Its gorge slopes include contrasting northerly and southerly aspects created by the large, tight radius meander the river has cut. The block also includes contrasting geologies due to its position near the contact of the Pottsville and Mauch Chunk formations. Rare communities include floodplain forests (high and low types), riverscours prairie, backwater slough, and Virginia pine forest. There also is some old-growth forest in this block.
- Mann's Creek-Fire Creek (1,209 ha [2,989 ac]) forest block is not entirely roadless in that it contains Sewell Road, which is currently gated and impassable to vehicles due to washouts. This block includes a large section of the Mann's Creek drainage and portions of Fire Creek and Ephraim Creek. Although there is no river frontage in this block due to the active

railroad that bounds the block on river right, the diversity of Ecological Land Units is the highest of any block in the analysis. Rare communities include cold cove forest along Mann's Creek and pitch pine woodlands. Much of the block is owned by West Virginia (Babcock State Park). If adjacent roadless areas outside the park boundaries are added, the size of this block is more than doubled.

- Big Branch (1,943 ha [4,803 ac]) forest block represents a roadless landscape in the southern part of the park. This block includes nearly the entire drainages of Big Branch, Kates Branch, and Mill Branch, and the lower part of Fall Branch. The geology is predominantly shale of the Mauch Chunk formation, which has eroded to a topography of rounded peaks (the highest in the park) in contrast to the flat sandstone capped plateaus formed by the Pottsville formation in the northern part of the park. The range in elevation in this block is the largest of all blocks in the analysis. No rare communities have been identified within this block but its mixed-mesophytic and oak-hickory forests are some of the most extensive and least fragmented in the park. This block contains a high proportion of private lands and these properties should be given high priority for acquisition or easement to preserve the integrity of this block. If adjacent roadless areas outside the park boundary are added, the size of this block is more than doubled, increasing its conservation value.
- Endless Wall (546 ha [1,350 acres]), a relatively small block, is included because it contains the best examples of cliff, Virginia pine, and hemlock communities found in the park. Maintaining this area as a roadless/rail-less block will help limit impacts of heavy recreational use that are already evident, especially in the cliff and pine communities.

Threats: The unfragmented character of the forested landscape within NERI is threatened by roads and urban encroachment. In addition, because many of the lands within the park boundary are still in private ownership, forest fragmenting practices (e.g., logging, development, and road building) are even a larger threat on these in-holdings.

Illegal and legal logging continues to occur within the authorized boundaries of NERI (NPS 1982; Gillespie Forestry Services 2002) and threatens all forests. In 2002, an illegal harvest of black cherry (*Prunus serotina*) and red oak on NPS lands occurred between Slater and Buffalo creeks (Gillespie Forestry Services 2002). Threats from logging include fragmentation of continuous forest cover and erosion from logging roads.

Gaps in Knowledge: Potential and future land use of properties located outside the park boundary are unknown. Development of these forested parcels will fragment the large continuous block of forest in which NERI is located.

#### Suggested Management Recommendations:

- Minimize development of fragmenting landscape features within large, continuous forest blocks at NERI.
- Prioritize private property acquisition and/or easements within large continuous forested blocks at NERI.
- Work with local municipalities to control land use adjacent to large continuous forested blocks at NERI.

## Mixed-mesophytic Forest

**Current Status and Significance:** The mixed-mesophytic forests of this region of the Allegheny Plateau where NERI is located are typically dominated by American beech, sugar maple, yellow poplar, hemlock, white oak, basswood, cucumber magnolia, and white ash (Braun 1950). This mixed-mesophytic forest type is maintained by small natural disturbance regimes, such as tree fall gaps, and in its climax state, supports vertical, structural, and compositional diversity (Vanderhorst 2001). The mixed-mesophytic forest reflects the cool-moist climate of the region. However, due to land-use history that caused disturbance by logging, mining, settlement, and fire, many of the historically mixed-mesophytic forest communities at NERI today are similar in composition to those of the Appalachian Oak Forest type as described by Stephenson et al. (1993). In fact, oak-hickory is the major forest cover type at NERI today (Grafton and Grafton 1980; Fortney et al. 1995; Suiter 1995). Prior to European settlement, oak was a minor component of the mixed-mesophytic forest, although oak-dominated forests may have existed on certain sites characterized by dry edaphic conditions and periodic fire (Abrams 1992). A large increase in oak, especially northern red oak, in mixed-mesophytic forests occurred after European settlement and associated cutting, burning, mining, and railroad activities (Abrams 1992). Therefore, many of the oaks that now exist at NERI may be a function of post-settlement activities rather than their natural distribution within the park (M. Abrams, 1998, The Pennsylvania State University, pers. comm.).

**Threats:** Although the mixed-mesophytic forest type appears to be regenerating at NERI, threats to this forest type include competition from nonnative species, deer overbrowsing, air pollution, and fragmentation due to roads, railways, logging, and urban encroachment. In addition, beech bark disease may threaten the mixed-mesophytic forests at NERI. The disease results when bark, attacked and altered by the beech scale (*Cryptococcus fagisuga*), is invaded and killed by fungi, primarily *Nectria coccinea* var. *faginata* and sometimes *N. galligena* (Houston and O'Brien 1983). Beech bark disease primarily kills big trees and control of this disease is difficult. The disease, although presently not found in NERI, may arrive at the park and contribute to beech mortality.

**Gaps in Knowledge:** The degree to which the mixed-mesophytic forest type is regenerating in NERI is unknown. Furthermore, no comprehensive monitoring of the health of this forest type has been conducted at NERI.

### **Suggested Management Recommendations:**

- Forest health monitoring plots should be expanded to include the mixed-mesophytic forest type. Resource managers should continue to monitor for the presence of beech bark disease in the park.
- The mixed-mesophytic forest type should be permitted to regenerate throughout NERI except in specific locations where oak-hickory, rimrock pines, or other vegetation were the preindustrial forest type.
- Deer hunting should continue to be permitted in NERI.
- The establishment and encroachment of nonnative plant species in the park should be prevented.

## Oak-hickory Forest

**Current Status and Significance:** The oak-hickory forest type is the most abundant (area covered) forest type in NERI today (Grafton and Grafton 1980; Vanderhorst 2001). Some researchers suggest that the oak-hickory forest is more common now than it was historically and is a function of post-settlement activities and industry (cutting and burning) (Vanderhorst 2001). Oak-dominated forests probably historically occurred in NERI on xeric sites but were more restricted in their distribution than they are today. These xeric oak sites may be historically significant as some of these sites contain some old-growth chestnut oaks in the park.

**Threats:** Forest composition research by Fortney et al. (1995) indicates a paucity of oak saplings and seedlings in oak stands within NERI. Their findings indicate that oak is not regenerating within NERI, a trend that is occurring throughout the Appalachians (Brose et al. 2001). Instead, oak stands are being replaced by mixed-mesophytic species such as maple, tulip poplar, and black gum (*Nyssa sylvatica*) (Fortney et al. 1995). There may be at least three reasons for the apparent lack of regeneration of oaks at NERI.

First, a history of fire suppression probably has limited the regeneration of oak-hickory forests at NERI. From 1500-1850, fires intentionally set by American Indians were used to achieve a variety of results including clearing land for agriculture, assisting in the management of favored vegetation, clearing routes of travel, herding game, and even waging war on neighboring tribes (Abrams 1992; Brose et al. 2001). These fires probably varied in intensity and exerted a considerable influence upon vegetative composition. One effect may have been creating a forested landscape that was comprised of the mixed-mesophytic forest interspersed with scattered stands of the oak-hickory forest type. From 1850-1950, increased European settlement and charcoal and iron production increased the frequency and intensity of fires in and around NERI, causing an expansion in the oak component of forests (Brose et al. 2001). In NERI, mining, railroad, and associated disturbances probably also lead to augmented oak regeneration in the early- to mid-1900s. Now that these early industrial conditions no longer exist, mixed-mesophytic forests are out-competing and replacing the oak-hickory forest type. Oak-hickory forests at NERI should be characterized as either true oak-hickory forests—those located on dry, rocky, or exposed habitats, or as vestige oak-hickory sites located on mesic habitats. Oaks on mesic sites should be allowed to undergo natural succession and convert back to the mixed-mesophytic forest type. Fire should be used with care to maintain an oak component in the NERI forests on the xeric oak-hickory sites (M. Abrams, 1989, The Pennsylvania State University, pers. comm.). Without some fire or disturbance management oaks may decline in NERI to below pre-European settlement distributions (Brose et al. 2001). At NERI, the greatest chance for the use of fire to successfully regenerate oak will occur on xeric sites due to limitations from competing species and more sunlight reaching the forest floor (M. Abrams, 1989, The Pennsylvania State University, pers. comm.). However, deer herbivory and nonnative species invasion are issues of concern on sites that have been treated by prescribed burning (T. Shuler, 2003, U.S. Forest Service, pers. comm.).

Second, the large deer herd at NERI may be limiting the success of oak regeneration in the park. Without control of the deer herd no fire regime will maintain oak forests in NERI. Oak is a preferred food to deer and continued grazing by deer will contribute to the replacement of oak by

species such as red maple that are less palatable to deer (Curtis and Sullivan 2001). Some research has found that a failure in oak regeneration following prescribed fire was attributed primarily to increased herbivory by deer (Schuler and McClain 2003).

Third, oak mortality caused by gypsy moths (*Lymantria dispar*) may have caused decline in oak in the Appalachians. This nonnative insect pest is a polyphagous defoliator but prefers oaks and true poplars (Montgomery and Wallner 1988). Although many oaks recover from defoliation caused by gypsy moths, repeated defoliation may lead to tree weakening and death (Wallner 1997). Trees weakened by defoliation are more susceptible to attack by secondary organisms such as the shoestring root rot fungus (*Armillaria mellea*) (Wargo 1977). Defoliation attributed to gypsy moth has declined dramatically over the last decade due to the introduction of a fungus (*Entomophaga maimaiga*) that is fatal to the pest and due to the application of a lethal bacteria, *Bacillus thuringiensis*. Occasional outbreaks of gypsy moth populations are still possible, however. The ridges, south-facing aspects, and dry plateau areas with a significant oak component have the potential for being most affected by this nonnative pest. If trees die due to defoliation, hazard tree loadings will increase. However, the moist climate at NERI may decrease the threat of hazard tree loadings contributing to wild fires. Nonnative plants, red maple, buckeye, yellow poplar, and other opportunistic species may invade gaps created by mortality of oaks.

In order to determine the population size and distribution of gypsy moths in the Appalachians, the Appalachian Integrated Pest Management Gypsy Moth Demonstration Project (AIPM) was started in 1988 (Weese 1992a, 1992b). Resource managers at NERI continue to monitor gypsy moth populations in hopes of keeping permanent damage to park natural resources at a minimum (Weese 1992a).

**Gaps in Knowledge:** Little information is available that indicates where oak-hickory forests existed in NERI prior to the industrialization period (pre-1920s). The natural fire regimes and accompanying forest condition need to be determined for the park. A comprehensive fire history for the park needs to be developed to help determine the historic role of fire in maintaining and/or creating selected vegetation communities at NERI. In addition, more information is needed on how to use fire to successfully regenerate oak-hickory forests on historic oak sites.

#### **Suggested Management Recommendations:**

- Forest health monitoring plots should be expanded to include the oak-hickory forest type. These plots should be placed in locales that are most suitable for oak regeneration and persistence.
- Determine what sites in NERI supported oak-hickory forests historically.
- Determine the fire history of NERI.
- Develop a management plan that includes fire as a tool to assist in the regeneration of these true oak-hickory sites.
- Deer hunting should continue to be permitted in NERI.
- The establishment and encroachment of nonnative plant species in the park should be prevented.

## Rimrock Pine Forest

**Current Status and Significance:** The rimrock pine forests occupy small acreage at NERI but contribute significantly to community diversity (Vanderhorst 2001). There are two types of rimrock pine communities at NERI: 1) pitch pine/scarlet oak (*Quercus coccinea*) and 2) Virginia pine. Both community types occur in narrow zones on sandstone rimrock located above cliffs in the northern section of NERI (Vanderhorst 2001) (Figure 3). Pitch pine communities are associated with westerly aspects on the edge of plateaus, but both pine communities occur on shallow soils that overlay sandstone bedrock. In addition, pine communities occur on sites that are rapidly drained, acidic, and nutrient poor. In other regions of the southeastern U.S. pitch pine communities are often associated with table mountain pine (*Pinus pungens*) but this is not the case in NERI (Vanderhorst 2001).

Pines along the ridge of the gorge were a dominant feature of the original forest at NERI as evident in historic photographs (J. Perez, 2003, NPS, pers. comm.). In addition, a stand of Virginia pine behind the Canyon Rim Visitor Center provides a valuable evergreen shield of the New River Gorge Bridge.

**Threats:** Although Virginia pine is probably more prevalent in NERI now than during the pre-European settlement period, it is declining (as is pitch pine) throughout its range, especially along cliffs and within the Appalachian flatrock community type (Vanderhorst 2001). These pines are an important component of the cliff communities at NERI which are currently threatened by increased visitor use and an absence of fire. In addition, the older Virginia pine stands at NERI are susceptible to southern pine beetle outbreak (B. Onken, 2003, U.S. Forest Service, pers. comm.). The understory of pitch pine stands in the park are dominated by striped maple (*Acer pensylvanicum*) and white pine (*Pinus strobus*) (both fire sensitive species) thus indicating no pitch pine regeneration within these stands (T. Shuler, 2003, U.S. Forest Service, pers. comm.).

**Gaps in Knowledge:** The ecology of the rimrock pine communities is not well-understood. For example, it is not known whether the light-demanding pine exists as an edaphic climax community on the rock outcrops along the rim or if it requires periodic fire for regeneration (M. Abrams, 1998, The Pennsylvania State University, pers. comm.; Welch and Waldrop 2001). These pine stands may regenerate from adjacent seed sources after fire, although the possibility of post-fire invasion of hardwoods and subsequent replacement of pine needs to be considered (M. Abrams, 1989, The Pennsylvania State University, pers. comm.).

### **Suggested Management Recommendations:**

- Forest health monitoring plots should be expanded to include pine communities. These plots should be placed in locales that are most suitable for rimrock pine regeneration and persistence (e.g., along cliff tops in the northern portion of the park).
- Determine what sites in NERI supported rimrock pine communities historically and the role of fire in the maintenance of these communities.
- Conduct a comprehensive dendrochronological analysis for the rimrock pine communities so that their ecological history can be better understood.

- Develop a management plan that includes fire as a tool to assist in the regeneration of these rimrock pine communities. Proper care and attention should be given to any prescribed burning approach to ensure viable regenerative sources are available for the burned areas.
- Deer hunting should continue to be permitted in NERI to reduce herbivory on regenerating pines.
- The establishment and encroachment of nonnative plant species in the park should be prevented.

### Eastern Hemlock Forest

**Current Status and Significance:** The hemlock forest type is considered rare at NERI and is typically present in small stands on the plateaus where it exists on shallow soils and in cool deep ravines along waterways (Suiter and Evans 1999) (Figure 3). These forests also contain red oak in the overstory and rhododendron (*Rhododendron maximum*) and mountain laurel (*Kalmia latifolia*) are common shrubs found in the understory (Suiter and Evans 1999). Hemlock stands provide an important forest cover type throughout the mid-Atlantic. They provide shade to streams, winter shelter to wildlife, and critical nesting cover to birds such as blackburnian warblers (*Dendroica fusca*) and black-throated blue warblers (*Dendroica caerulescens*) (Mahan et al. 2004).

**Threats:** Hemlocks are threatened throughout the mid-Atlantic by a nonnative insect pest, the hemlock woolly adelgid (*Adelges tsugae*), that attacks and kills hemlock trees (McClure 1991). Although this insect pest is not currently documented in the park, resource managers at NERI have established forest health monitoring plots in hemlock stands throughout NERI (J. Perez, 2003, NPS, pers. comm.).

**Gaps in knowledge:** Unknown.

#### **Suggested Management Recommendations:**

- Establish an active protection and detection program for hemlock woolly adelgid at NERI. In order to protect the hemlock resource, it is critical to have an active protection/detection program. The earlier the detection of infestation, the more options there are for treatment.
- Maintain forest health monitoring plots in hemlock stands throughout the park.
- Encourage hemlock regeneration by preventing the establishment and encroachment of nonnative plant species in the park and by permitting hunting of white-tailed deer.

### Old-growth Forest

**Current Status and Significance:** Due to past land-use history, no large old-growth (>200 years old) stands exist in NERI today. A few individual old trees, however, still exist in the park, mainly on steep slopes of the gorge. In particular, red cedar, hemlock, and chestnut oak may reach old ages on rock escarpments that were inaccessible to loggers (Fortney et al. 1995). For example, Fortney et al. (1995) documented a red cedar tree that exceeded 175 years old on a rock escarpment near a peregrine falcon hacking site at the top of the New River Gorge.

Greenberg et al. (1997) provide a definition and the distinguishing characteristics for old-growth, mixed-mesophytic forests of the eastern U.S. In general, old-growth mixed-mesophytic forests contain, on average, a stand basal area of 38 m<sup>2</sup>/ha (165 ft<sup>2</sup>/ac), trees that range in age from 190-600 years old, trees with a range of dbhs of 100-195 cm (39-77 in), an average of 31 standing snags per ha (12.5 standing snags per ac), 9.5 percent of the canopy in some sort of gap phase, and 155 m<sup>3</sup>/ha (2616 ft<sup>3</sup>/ac) of downed logs (Greenberg et al. 1997).

Threats: Past logging and land-use activities removed old-growth forests from NERI.

Gaps in Knowledge: Location and number and species of remaining old-growth trees in NERI are unknown.

Suggested Management Recommendations:

- Protect existing forests from removal and encourage regeneration and natural processes (tree fall gaps) to permit the old-growth forest type to return to NERI.
- Map known old-growth trees in park.

### Cliff Communities

Current Status and Significance: The cliff habitats at NERI are the least studied and understood community type in the park. In general, cliff ecosystems contribute greatly to the regional biodiversity of plants and animals (Larson et al. 2000, Figure 3). Although little is known about this habitat type in NERI, the cliff environment may support specific species of plants (e.g., cliff ferns, old-growth cedars), reptiles (e.g., coal skink), amphibians (e.g., green salamander), and invertebrates (e.g., terrestrial gastropods).

Threats: Research is needed in this habitat type in order to determine what species are found on the cliffs and to understand the potential impacts of recreational rock-climbing on these species. The continued popularity and expansion of recreational rock-climbing in NERI may threaten these natural resources. For example, researchers have found that rock-climbing can lead to decreased abundance and richness of vascular and nonvascular plants and lichens (McMillan and Larson 2002), indicating that the entire biotic community may be affected (McMillan et al. 2003).

Gaps in Knowledge: No research has been conducted to determine the community of organisms that use the cliff faces at NERI.

Suggested Management Recommendations:

- Plant and animal species monitoring plots (similar to forest health monitoring plots) should be expanded to include cliff communities. These plots should be placed in two different locales: 1) areas that are not used by rock climbers, and 2) along popular climbing routes. These plots will help determine what effects rock-climbing is having on the cliff communities of NERI.
- A detailed inventory of flora and fauna using cliffs at NERI should be conducted.

## Riparian Communities Including Appalachian Flatrock Community

Current Status and Significance: Natural riparian areas are some of the most diverse, dynamic, and complex biophysical habitats in the terrestrial environment (Naiman et al. 1993). The floodplain riparian area includes the stream channel between low- and high-water marks. The riparian area also encompasses that portion of the terrestrial landscape above the high-water mark where vegetation may be influenced by elevated water tables or flooding and by the ability of soils to hold water (Naiman and Decamps 1997). In addition, riparian areas are characterized by exposure to long periods of seasonal flooding (Malanson 1993).

Buhlmann and Vaughan (1987) and Buhlmann et al. (1987) characterized riparian areas within NERI and developed an extensive list of plants associated with riparian habitats. Buhlmann et al. (1987) recognized 10 riparian habitat types at NERI: mature sycamore, willow, sycamore-willow-birch, stunted sycamore-willow, hemlock/rip-rap, riparian Virginia pine (Appalachian flatrock), rock riprap, boulder, tributary, and developed.

The Appalachian flatrock community type is a globally rare ecological community that is composed of locally rare sedges, cedars, pines, and other plants and is known from three sites in NERI (Buhlmann et al. 1987; Suiter and Evans 1999; Vanderhorst 2001) (Figure 3). This community occurs on flat sandstone ledges along the New River and is dependent on the scouring caused by occasional flooding for its long-term integrity (Buhlmann et al. 1987).

There are actually two types of Appalachian flatrock communities at NERI: 1) high flatrock and 2) low flatrock. The high flatrock community is a globally rare community type and is found primarily at Camp Brookside and Sandstone Falls (Mitchem and Johnson 2001). The high flatrock community constitutes about 4.5 ha (11 acres) in the park. Keeny Creek-Flatrock represents the only low flatrock community in NERI. The overstory of all Appalachian flatrock community sites is dominated by Virginia pine and eastern red cedar, with some post oak (*Quercus stellata*) growing in association with these conifers (Mitchem and Johnson 2001). Currently, understories of Appalachian flatrock communities at NERI are dominated by hardwood species, such as red oak, red maple, black cherry, white ash, and pawpaw (*Asimina triloba*), and have little or no regeneration of the light-demanding conifer species such as Virginia pine and red cedar (Mitchem and Johnson 2001).

Anecdotal evidence indicates that, historically, the New River experienced catastrophic floods every 50 to 100 years. Sites exposed to high water and current were severely eroded, or perhaps eliminated, while other similar types of sites were created (Johnson 2002). This harsh environment led to development of a special community that thrived on the flatrock sandstone shelves immediately above the river in association with rapids (Johnson 2002). Here, the distinctive Appalachian flatrock community survived on a thin layer of infertile sandy soil and consisted of species normally associated with more xeric conditions than those typically found on a river bottom (Johnson 2002). These species retained their early succession dominance over time because of the regular flooding and poor site fertility (Vandershorst 2001; Johnson 2002). With construction of the Bluestone Dam and consequent reduction in catastrophic flooding, species characteristic of other riparian and mesophytic communities began invading the flatrock

shelves. Furthermore, regulation of waterflow in the New River has caused the soil layer at sites to accumulate, thus permitting hardwood species and nonnatives to invade.

Threats: The Appalachian flatrock community sites within NERI are Keeny Creek, Camp Brookside, and Sandstone Falls. Site-specific threats are listed with a description of each site as follows:

- Keeny Creek flatrock community represents the only low Appalachian flatrock community in NERI. A relatively small but pristine site, the flatrock exposure here supports populations of six plant species of special concern in West Virginia (Rouse and McDonald 1986). Located in a remote area of the New River Gorge portion of NERI, there are few immediate threats except for the railroad right-of-way (ROW). Care should be taken in the maintenance of this ROW not to disturb this rare community.
- Camp Brookside, situated along the river at Brooks Falls, is the largest and best example of the high Appalachian river flatrock community within NERI. This area contains the largest known concentration of plant species of special concern within NERI (Rouse and McDonald 1986). This site is threatened by use as a fishing site and portage location. In 2002, fire was used controversially as a surrogate for flooding disturbance to help maintain the Camp Brookside flatrock community (Johnson 2002). Continued monitoring will determine if the mixed red cedar and juniper (*Juniperus* sp.) will return to the burned sites.
- Sandstone Falls, a high Appalachian flatrock community site, supports three plant species of special concern in West Virginia. The only known location for annual fimbry (*Fimbristylis annua*) in West Virginia is from this site (Rouse and McDonald 1986). This area is impacted from past and current disturbances, including livestock grazing and heavy unrestricted recreational use throughout the site.

Currently, the understories of all Appalachian flatrock communities in NERI are dominated by hardwood species and have little or no regeneration of the light-demanding conifer species such as Virginia pine and red cedar (Mitchem and Johnson 2001).

Gaps in Knowledge: Other than a cursory understanding of the presence of plant species in the Appalachian flatrock communities, the riparian zones in NERI are unstudied. For example, it is not known how healthy these areas are and if they are functioning properly to afford the park's water resources maximum ecological protection given the history of flow regulation (Purvis et al. 2002). In addition, the effects of the use of fire to simulate flood-mediated disturbance in Appalachian flatrock communities are not well known.

Suggested Management Recommendations:

- Conduct a comprehensive dendrochronological analysis for the Appalachian flatrock communities so that their ecological history can be better understood.
- Compare the New River riparian communities to those on rivers that have unregulated and relatively unstressed conditions. This type of comparison may help determine how regulated flow affects the native communities in the park, given that NERI has its own unique geomorphology and discharge characteristics.
- Identify bottomland surface features throughout the park and overlay these features with maps of the vegetation communities to determine how bottomland surfaces and flow dynamics affect terrestrial ecosystems.

- Restrict visitor use of the Appalachian flatrock community type.
- Continue monitoring the Camp Brookside flatrock community to determine if fire is an appropriate tool to simulate flood-mediated disturbances.

### Wetlands, Springs, and Seeps

**Current Status and Significance:** The National Wetlands Inventory (NWI) of the U.S. Fish and Wildlife Service (USFWS) shows the location, type, and distribution of wetlands as small as 0.5 ha (1.2 acre) (U.S. Fish and Wildlife Service 2002). NWI indicates that the most dominant wetland types found in NERI are temporarily flooded riverine wetlands on unconsolidated or rocky shores, permanently flooded riverine wetlands, and temporarily flooded, broad-leaved deciduous palustrine wetlands. Specific descriptions of all wetland types are provided by Cowardin et al. (1979).

Although a detailed wetland map is needed for NERI, a detailed wetland delineation study (indicating wetlands smaller than 0.5 ha [1.2 ac] in size) was conducted for the park by the West Virginia Department of Transportation (WV DOT) between Hinton and the I-64 bridge (Purvis et al. 2002). For this section of NERI, 79 wetlands representing 21 wetland types were identified. These findings contrast with the NWI maps that only show 49 wetlands of 11 types in this section of NERI. In contrast to the NWI, the most common wetland type identified by the WV DOT study was broad-leaved deciduous palustrine wetland, followed by riverine wetlands.

A detailed study has been made of the locally significant Kates Branch Wetland located near springs of Glade Creek's Kates Branch (Eye 1981). Several species of rare plants including many that reach their southernmost or northernmost distributional limits were found within the wetlands (Eye 1981).

**Threats:** Poor water quality and development of roads and controlled flow of the New River potentially threaten wetlands in NERI.

**Gaps in Knowledge:** No detailed wetland map (a map showing wetlands <0.5 ha [<1.2 ac]) is available for NERI.

**Suggested Management Recommendations:**

- Limit visitor use and disturbance of wetlands in NERI.
- Do not permit new construction in wetland areas of NERI.
- Create a detailed wetland map for NERI.

### Aquatic Plants

**Current Status and Significance:** Weeks et al. (1997) conducted surveys of development sites for algae and other aquatic plants. Many of the tributaries that they surveyed contained algal species that are indicators of salt brine, sewage, and oil (Weeks et al. 1997). Complete species lists are provided in Weeks et al. (1997). Rutherford (1999) described periphyton assemblages in 10 selected tributaries to New River within NERI. The study identified 106 species of algae, mostly

diatoms. The high abundance and frequency of the algae, *Schizothrix calcicola*, indicated that human waste was a major contributor to pollution in many of these streams.

The dominant macrophyte in NERI is water star-grass (*Heteranthera dubia*), a plant often associated with mussel beds in the New River (Buhlmann and Vaughan 1987; Jirka and Neves 1987; Buhlmann 1990). Aside from their association with mussel beds, these aquatic plants provide habitat for macroinvertebrates and fish in the New River. Pondweed (*Potamogeton* spp.) and Nuttall waterweed (*Elodea* sp.) are also common in the New River and are often present in mussel beds (Buhlmann and Vaughan 1987; Jirka and Neves 1987; Buhlmann 1990). The size of *Elodea* beds within NERI have increased in recent years, perhaps due to increased eutrophication of the New River (Buhlmann 1990).

Threats: Poor water quality and associated eutrophication may increase the abundance of some algae and plant species in the streams of NERI. However, increased eutrophication also threatens to eliminate or restrict the distribution of certain aquatic plant species in NERI (Weeks et al. 1997).

Gaps in Knowledge: The effect of water quality on the distribution and abundance of aquatic plants has not been well studied at NERI.

Suggested Management Recommendations:

- Monitor aquatic plants and algae to use as surrogate indicators of water quality in the park.
- Maintain aquatic grass beds in NERI to ensure healthy populations of native mussels and macroinvertebrates.

#### Nonvascular Plants, Lichens, and Fungi

Current Status and Significance: Weeks et al. (1997) conducted the only known survey specifically for lichens and nonvascular plants at NERI. NPSpecies (2003) only has records for 14 species of nonvascular plants (mostly mosses) and only 32 species records for fungi from NERI.

Threats: Unknown.

Gaps in Knowledge: Despite their importance to terrestrial and freshwater communities, little is known about the distribution and abundance of these species.

Suggested Management Recommendations:

- Expand the survey effort for lichens, fungi, and nonvascular plants in NERI.
- Lichen surveys should be conducted on cliff faces.

#### Plant Species of Special Concern

Grafton and Grafton (1980) provided a comprehensive list of plant species, including habitat associations and locations, found within NERI that are considered of special concern in West Virginia by the West Virginia Natural Heritage Program (WV NHP; Table 1). In addition,

Table 1. List of plant species and communities of special concern in West Virginia known to occur in New River Gorge National River according to the West Virginia Natural Heritage Program, 2004. No federally listed species of plants are known to currently occur in the park.

Scientific Name	Common Name	State Ranking <sup>1</sup>	Global Ranking <sup>2</sup>
Communities			
<i>Juniperus virginiana</i> - <i>pinus virginiana</i>	Appalachian flatrock community	S1	G2
Species			
<i>Coreopsis pubescens</i> var. <i>robusta</i>	star tickseed	S2	G5
<i>Eupatorium pilosum</i>	vervain thoroughwort	SH	G5
<i>Helianthus occidentalis</i> ssp. <i>occidentalis</i>	McDowell sunflower	S2	G5
<i>Silphium perfoliatum</i> var. <i>connatum</i>	Virginia cup-plant	S1	G5
<i>Arabis hirsuta</i> var. <i>pycnocarpa</i>	hairy rock-cress	S2	G5
<i>Cardamine flagellifera</i>	bittercress	S2	G3
<i>Silene nivea</i>	snowy campion	S1	G4
<i>Hypericum denticulatum</i>	coppery St. John's-wort	S1	G5
<i>Cuscuta indecora</i>	pretty dodder	S1	G5
<i>Croton glandulosus</i> var. <i>septrionalis</i>	sand croton	S2	G5
<i>Baptisia australis</i>	wild false indigo	S3	G5
<i>Desmodium lineatum</i>	tick-trefoil	SH	G5
<i>Galactia volubilis</i>	downy milkpea	S1	G5
<i>Gentiana austromontana</i>	Appalachian gentian	S1	G3
<i>Pycnanthemum incanum</i> var. <i>puberulum</i>	hoary mountain-mint	S1	G4
<i>Pycnanthemum torrei</i>	Torrey's mountain-mint	S1	G2
<i>Pycnanthemum loomisii</i>	Loomis' mountain-mint	S1	G4
<i>Scutellaria saxatilis</i>	rock skullcap	S2	G3
<i>Stachys nuttallii</i>	Nuttall's hedge-nettle	S3	G5
<i>Stachys tenuifolia</i> var. <i>tenuifolia</i>	smooth hedge-nettle	S2	G5
<i>Lythrum alatum</i>	winged-loosestrife	S2	G5
<i>Hibiscus laevis</i>	halberd-leaved mallow	S2	G5
<i>Sida hermaphrodita</i>	Virginia mallow	S2	G2
<i>Oenothera pilosella</i>	evening-primrose	S2	G5
<i>Polygala curtissii</i>	Curtis milkwort	S2	G5

Table 1. List of plant species and communities of special concern in West Virginia known to occur in New River Gorge National River according to the West Virginia Natural Heritage Program, 2004. No federally listed species of plants are known to currently occur in the park (continued).

Scientific Name	Common Name	State Ranking <sup>1</sup>	Global Ranking <sup>2</sup>
<i>Eriogonum allenii</i>	yellow buckwheat	S2	G4
<i>Ranunculus pusillus</i>	low spearwort	S1	G5
<i>Thalictrum steeleanum</i>	Steele's meadow rue	S1	G3
<i>Thalictrum clavatum</i>	mountain meadow-rue	S1	G4
<i>Salix lucida</i>	shining willow	S1	G5
<i>Saxifraga careyana</i>	Carey's saxifrage	S3	G3
<i>Vitis rupestris</i>	sand grape	S1	G3
<i>Commelina erecta</i>	slender dayflower	S2	G5
<i>Carex aestivalis</i>	summer sedge	S2	G4
<i>Carex careyana</i>	Carey's sedge	S1	G5
<i>Carex comosa</i>	bearded sedge	S2	G5
<i>Carex emoryi</i>	Emory's sedge	S1	G5
<i>Carex mesochorea</i>	midland sedge	SH	G4
<i>Carex molesta</i>	troublesome sedge	S1	G4
<i>Carex styloflexa</i>	bent sedge	S1	G4
<i>Carex suberecta</i>	prairie straw sedge	S1	G4
<i>Carex typhina</i>	cat-tail sedge	S2	G5
<i>Carex woodii</i>	pretty sedge	S1	G4
<i>Cyperus refractus</i>	reflexed flatsedge	S2	G5
<i>Eleocharis intermedia</i>	matted spikerush	S1	G5
<i>Eleocharis compressa</i>	flat-stemmed spikerush	S2	G4
<i>Fimbristylis annua</i>	annual fimbry	S1	G5
<i>Rhynchospora recognita</i>	globe beaked-rush	S2	G5
<i>Scirpus purshianus</i>	weakstalk bulrush	S2	G4
<i>Najas gracillima</i>	slender water nymph	S2	G5
<i>Calopogon tuberosus</i> var. <i>tuberosus</i>	grass pink	S1	G5
<i>Corallorhiza wisteriana</i>	spring coralroot	S1	G5
<i>Platanthera psycodes</i>	small purple-fringe orchis	S1	G5

Table 1. List of plant species and communities of special concern in West Virginia known to occur in New River Gorge National River according to the West Virginia Natural Heritage Program, 2004. No federally listed species of plants are known to currently occur in the park (continued).

Scientific Name	Common Name	State Ranking <sup>1</sup>	Global Ranking <sup>2</sup>
<i>Pogonia ophioglossoides</i>	rose pogonia	S2	G5
<i>Spiranthes tuberosa</i>	little ladies'-tresses	S2	G5
<i>Triphora trianthophora</i>	nodding pogonia	S2	G3
<i>Aristida purpurascens</i>	purple needlegrass	S1	G5
<i>Melica mutica</i>	two-flower melic grass	S2	G5
<i>Piptochaetium avenaceum</i>	blackseed needlegrass	S1	G5
<i>Poa saltuensis</i>	drooping bluegrass	SH	G5
<i>Sporobolus clandestinus</i>	rough dropseed	S1	G5
<i>Woodsia scopulina</i>	Allegheny cliff fern	S2	G5

<sup>1</sup>State rankings (ST STATUS):

S1 five or fewer documented occurrences, or very few remaining individuals within the state. Extremely rare and critically imperiled.

S2 six to 20 documented occurrences, or few remaining individuals within the state. Very rare and imperiled.

S3 twenty-one to 100 documented occurrences. May be somewhat vulnerable to extirpation.

H historical occurrence modifier; historically occurred but has not been documented in this location during latest plant surveys.

<sup>2</sup>The Nature Conservancy Global Rankings (TNC STATUS):

These are global rankings assigned by the Nature Conservancy (now Nature Serve).

G1 five or fewer documented occurrences, or very few remaining individuals globally. Extremely rare and critically imperiled.

G2 six to 20 documented occurrences, or few remaining individuals globally. Very rare and imperiled.

G3 twenty-one to 100 documented occurrences. Either very rare and local throughout its range or found locally in a restricted range; vulnerable to extinction.

G4 common and apparently secure globally; though it may be rare in parts of its range, especially at the periphery.

G5 very common and demonstrably secure, though it may be rare in parts of its range, especially at the periphery.

several plant surveys initiated by the WV NHP have been conducted in NERI in recent years (Eye 1981; Rouse 1986; Rouse and McDonald 1986; McDonald and Harmon 1989; Suiter 1995; McDonald 1998; Suiter and Evans 1999). Currently, over 60 plant taxa of special concern in West Virginia have been reported from NERI (Suiter and Evans 1999). Since the mid-1980s, a handful of globally rare and/or federally listed plant species have been studied in or near NERI. They include: Virginia spiraea (historically occurred but not currently documented in the park), running buffalo clover (not currently documented in the park), Steele's meadow rue (*Thalictrum steeleanum*), and bittercress (*Cardamine flagellifera* and *C. clematitis*).

#### Virginia Spiraea:

*Current Status and Significance:* Virginia spiraea is a federally threatened, disturbance-adapted shrub. Populations are restricted to steeply sloped riparian sites where arboreal competition is inhibited by erosion and periodic flooding. Although Virginia spiraea has not recently been documented within NERI, it did occur historically along the New River below Hawks Nest Dam in the 1960s (Ogle 1991) and was found 0.8 km (0.5 mile) above Cotton Hill in the 1950s (Grafton and Grafton 1980).

*Threats:* The distribution and establishment of Virginia spiraea are restricted by arboreal competition in areas where flooding disturbance has been restricted and by competition with nonnative species of plants (Ogle 1991).

*Gaps in Knowledge:* Although currently not documented in NERI, resource managers are unsure if Virginia spiraea currently occurs in the park.

#### *Suggested Management Recommendations:*

- Conduct a survey for Virginia spiraea along the New River and its tributaries.
- Restrict human use of any sites where this species is found.
- Potentially reestablish this species in the Appalachian flatrock community along the New River.
- Manual disturbance to simulate the effects of flooding and removal of nonnatives could be implemented in order to reestablish this species at NERI.

#### Running Buffalo Clover:

*Current Status and Significance:* Running buffalo clover was listed as a federally endangered species in 1987 (Bartgis 1989). In West Virginia, a population of this species was documented on a small sandy floodplain in NERI by Bartgis (1989). Pauley et al. (1997) were unable to relocate this species in NERI; however, this species was observed in 2000 on the Cotton Hill floodplain in NERI (W. Grafton, 2004, West Virginia University, pers. comm.).

*Threats:* Competition with nonnative plant species seems to be impeding the spread, and perhaps continued persistence, of this species in NERI (Bartgis 1989). Restrictions in flooding due to the construction of Bluestone Dam may have encouraged the spread and persistence of nonnative competing vegetation species and negatively affected this disturbance-adapted species.

*Gaps in Knowledge:* Although not currently documented at NERI, resource managers are unsure if the species still occurs on the sandy floodplains in the park.

*Suggested Management Recommendations:*

- Conduct a survey for running buffalo clover along New River and its tributaries in the park. Re-visit the Cotton Hill floodplain to look for this species.
- Restrict human use of any sites where this species is found.
- Manual disturbance to simulate the effects of flooding and removal of nonnatives could be implemented to ensure the persistence of this species at NERI.

*Steele's Meadow Rue:*

*Current Status and Significance:* Steele's meadow rue prefers well-drained wooded slopes with relatively open understory. This species still is being considered for federal listing as threatened or endangered (Rouse and McDonald 1986). Three populations of this species are documented within NERI (Rouse and McDonald 1986; McDonald and Harmon 1989).

*Threats:* Two populations of this species are vulnerable at NERI due to their location near roads and powerline rights-of-way and provisions should be made to ensure that routine maintenance of these areas does not inadvertently impact these populations.

*Gaps in Knowledge:* The distribution of this species in the park is not well known.

*Suggested Management Recommendations:*

- Additional surveys should be conducted to locate populations of this species within NERI.
- In order to ensure the persistence of this species in NERI, encroachment and establishment of nonnative plant species should be prevented and hunting of white-tailed deer should be continued.

*Bittercress:*

*Current Status and Significance:* Rouse and McDonald (1986) and McDonald and Harmon (1989) identified two species of bittercress, *Cardamine clematidis* and *C. flagellifera*, as globally rare (100 or fewer occurrences worldwide), and *C. clematidis* is being considered for federal listing (Pauley et al. 1997). However, there is some confusion about the taxonomy of the *Cardamine* in NERI (McDonald and Harmon 1989). Both species are southern Appalachian endemics, reach their northern limit in West Virginia, and are found in West Virginia only within NERI (Rouse and McDonald 1986; McDonald and Harmon 1989; Pauley et al. 1997). A large population of *C. flagellifera* is located on the river left floodplain between Coal Run and Red Ash Island (J. Perez, 2004, NPS, pers. comm.). These species prefer rich, mesic forested floodplains.

*Threats:* Populations of these species located near Stonecliff are particularly vulnerable due to their proximity to a dirt road that starts at the Stonecliff bridge (Rouse and McDonald 1986; McDonald and Harmon 1989).

*Gaps in Knowledge:* The distribution of these species within NERI is not well known.

*Suggested Management Recommendations:*

- Careful consideration should be given to these plant populations prior to implementing road improvements or increasing vehicle use (Rouse and McDonald 1986; McDonald and Harmon 1989).
- Additional surveys should be conducted to locate populations of this species in NERI as they are likely to be found especially within the gorge itself.
- In order to ensure the persistence of this species in NERI, encroachment and establishment of nonnative plant species should be prevented and hunting of white-tailed deer should be continued.

Hazard Trees

**Current Status and Significance:** Because NPS policies require that a park guarantee the protection of resources while providing for safety of visitors, NERI developed a hazard-tree abatement plan in 1992 (Weese 1992b). A hazard tree is any tree, or portion of a tree, located in an area of regular traffic or occupancy by persons or property and that is in imminent danger of failure or collapse due to some recognizable defect (Weese 1992b).

Twenty-six visitor-use areas were identified where tree inspections and tree removal should occur if hazard trees are identified as being at risk to visitors (Weese 1992b). Because most of these sites are located in association with development sites, tree removals in these areas should have little to no effect on intrinsically significant natural resources.

**Threats:** As forests age, hazard tree loading may increase, potentially increasing the risk of fire. In the eastern U.S., however, high humidity and rapid decay greatly reduces the fire risk (T. Schuler, 2003, U.S. Forest Service, pers. comm.).

**Gaps in Knowledge:** Unknown.

*Suggested Management Recommendations:*

- Two hazard tree abatement sites listed in the hazard-tree abatement plan correspond with the globally rare flatrock community found within NERI, and consultation with natural resource managers should occur prior to the removal of vegetation from these sites.

Nonnative Plants

**Current Status and Significance:** The invasion of nonnative plants may be the biggest threat to maintaining native forests and plant communities at NERI, but, in reality, not all nonnatives can be controlled or removed. Some nonnative plants that may be particularly deleterious at NERI are purple loosestrife (threatens Virginia spiraea habitat), Japanese knotweed, Japanese honeysuckle, garlic mustard, tree-of-heaven, privet, paulownia, and kudzu (Bartgis 1989; Davis 1995). Kudzu is a very pervasive nonnative plant at NERI. For example, some of the kudzu patches are 12.1 ha (30 ac) in size and stretch from the railroad upslope to almost the rim of the gorge (J. Perez, 2003, NPS, pers. comm.). This nonnative species is primarily a threat to cultural resources as it can grow across historic buildings and damage their exterior.

Threats: None.

Gaps in Knowledge: The number, distribution, and continued encroachment of nonnative plants at NERI is not well known or studied.

Suggested Management Recommendations:

- Prevent the establishment and encroachment of nonnative plants through manual removal, select use of herbicides, and minimizing fragmenting features such as roads in the park.
- Develop and implement a plan to control invasive nonnative plant species in the park.

## Animal Resources

### Mammals

There are 63 species of mammals known to occur in NERI (NPSpecies 2003). West Virginia Gap Analysis (2003) predicts NERI to contain 91.5% (54 of 59 species) of the mammalian species known to occur in West Virginia and 77% (17 of 22 species) of the mammalian species of special concern in West Virginia. Federally listed mammalian species known to occur within NERI include Virginia big-eared bat (*Corynorhinus townsendii virginianus*) and Indiana bat (*M. sodalis*) (Table 2).

#### White-tailed Deer:

*Current Status and Significance:* According to the West Virginia Department of Natural Resources (WV DNR), the state population of white-tailed deer is just under one million individuals (WV DNR 2003). In District IV, the game zone designated by the WV DNR in which NERI is located, deer densities are approximately 13 deer/km<sup>2</sup> (33 deer/mi<sup>2</sup>) of available deer habitat (WV DNR 2003). These deer densities contrast with estimates of pre-European settlement deer densities of approximately 3-8 deer/km<sup>2</sup> (8-20 deer/mi<sup>2</sup>) on the Appalachian plateau (Horsely et al. 2003).

The high populations of white-tailed deer in the eastern U.S. in the late 20<sup>th</sup> and early 21<sup>st</sup> centuries have reduced plant diversity, caused forest regeneration failure, and have had secondary impacts on other wildlife communities (Horsely et al. 2003). The WV DNR has recognized this population increase and has adjusted hunting regulations in an effort to control the growing herd. The increase of crop damage complaints, vehicle collisions, damage to natural vegetation communities, and the realistic risk of catastrophic disease are driving game managers to control deer numbers (S. Pugh, 2003, NPS, pers. comm.). In 2002, there were 29,927 deer harvested by firearm in District IV. Within that district, 47 deer were recorded as being harvested within NERI. Hunters probably harvested more deer within NERI but failed to indicate locations on harvest report cards.

*Threats:* White-tailed deer are potentially threatened by chronic wasting disease. Chronic wasting disease (CWD) is a neurological (brain and nervous system) disease found in deer and elk in certain geographical locations in North America (WV DNR 2003). The disease belongs to a family of diseases known as transmissible spongiform encephalopathies (TSE) or prion

Table 2. Vertebrates (excluding birds) and invertebrates of special concern in West Virginia known to occur in New River Gorge National River, 2004. Birds are not considered in this table because they currently are not classified by the West Virginia Heritage Program in the same manner as other vertebrates due to their variety of occurrence (breeding, migratory, and resident) within the state.

Scientific Name	Common Name	State Rank <sup>1</sup>	Global Rank <sup>2</sup>	Federal Rank
Mammals				
<i>Myotis sodalis</i>	Indiana bat	S1	G2	endangered
<i>Corynorhinus townsendii</i>	Virginia big-eared bat	S2	G4	endangered
<i>Myotis leibii</i>	small-footed myotis	S1	G3	
<i>C. rafinesque</i>	eastern big-eared bat	S1	G3	
<i>Sorex dispar</i>	long-tailed shrew	S2	G4	
<i>Sorex hoyi winnemana</i>	southern pygmy shrew	S2	G5	
<i>Ochrotomys nuttalli</i>	golden mouse	S2	G5	
<i>Neotoma magister</i>	Allegheny woodrat	S3	G3	
Reptiles				
<i>Eumeces laticeps</i>	broad-headed skink	S2	G5	
<i>Opheodrys aestivus</i>	rough greensnake	S3	G5	
<i>Carphophis amoenus</i>	eastern worm snake	S3	G5	
<i>Pseudemys concinna</i>	river cooter	S2	G5	
<i>Graptemys geographica</i>	common map turtle	S2	G5	
Insects				
<i>Cicindela ancocisconensis</i>	tiger beetle	S3	G3	
<i>Speyeria diana</i>	Diana fritillary	S2	G3	
Amphibians				
<i>Ambystoma jeffersonianum</i>	Jefferson salamander	S3	G4	
<i>Aneides aeneus</i>	green salamander	S3	G3	
<i>Desmognathus quadramaculatus</i>	black-bellied salamander	S3	G5	
<i>Eurycea lucifuga</i>	cave salamander	S3	G5	
<i>Plethodon kentucki</i>	Cumberland plateau salamander	S2	G4	
<i>Pseudotriton ruber</i>	northern red salamander	S3	G5	

Table 2. Vertebrates (excluding birds) and invertebrates of special concern in West Virginia known to occur in New River Gorge National River, 2004. Birds are not considered in this table because they currently are not classified by the West Virginia Heritage Program in the same manner as other vertebrates due to their variety of occurrence (breeding, migratory, and resident) within the state (continued).

Scientific Name	Common Name	State Rank <sup>1</sup>	Global Rank <sup>2</sup>	Federal Rank
Fish				
<i>Nocomis platyrhynchus</i>	bigmouth chub	S3	G4	
<i>Notropis scabriceps</i>	New River shiner	S2	G4	
<i>Phoxinus oreas</i>	mountain redbelly dace	S3	G5	
Mussels				
<i>Lasmigona subviridis</i>	green floater	S2	G3	
<i>Tritogonia verrucosa</i>	pistolgrip	S2	G4	
<i>Alasmidonta marginata</i>	elktoe mussel	S2	G4	
<i>Cyclonaias turberculata</i>	purple wartyback	S1	G5	
<i>Elliptio dilatata</i>	spike mussel	S2	G5	
<i>Lampsilis fasciola</i>	wavy-rayed lampmussel	S2	G4	
<i>Lampsilis ovata</i>	pocketbook mussel	S1	G5	
<i>Quadrula quadrula</i>	maple leaf	S2	G5	

<sup>1</sup>State rankings:

S1 five or fewer documented occurrences, or very few remaining individuals within the state. Extremely rare and critically imperiled.

S2 six to 20 documented occurrences, or few remaining individuals within the state. Very rare and imperiled.

S3 twenty-one to 100 documented occurrences. May be somewhat vulnerable to extirpation.

SA rare in the state but an accidental occurrence.

<sup>2</sup>The Nature Conservancy Global Rankings (TNC STATUS):

These are global rankings assigned by the Nature Conservancy (now NatureServe).

G1 five or fewer documented occurrences, or very few remaining individuals globally. Extremely rare and critically imperiled.

G2 six to 20 documented occurrences, or few remaining individuals globally. Very rare and imperiled.

G3 twenty-one to 100 documented occurrences. Either very rare and local throughout its range or found locally in a restricted range; vulnerable to extinction.

G4 common and apparently secure globally; though it may be rare in parts of its range, especially at the periphery.

G5 very common and demonstrably secure, though it may be rare in parts of its range, especially at the periphery.

diseases. The disease attacks the brains of infected deer and elk which results in the death of the animal. While CWD is similar to mad cow disease in cattle and scrapie in sheep, there is no known relationship between CWD and any other TSE of animals or people. CWD has not been found in any animals in West Virginia. The WV DNR Wildlife Resources Section, in cooperation with the Southeast Cooperative Wildlife Disease Study at the University of Georgia, College of Veterinary Medicine, has tested free-ranging deer from West Virginia for CWD every year beginning in 2000. However, to detect a disease that is present in only a few animals, a large number of samples need to be tested to be absolutely sure CWD is not present in free-ranging deer in West Virginia. Therefore, the WV DNR is testing a large number of deer for CWD throughout the state and will continue testing as long as the disease threat is present (WV DNR 2003).

*Gaps in Knowledge:* The actual harvest numbers for white-tailed deer from NERI are unknown. A more accurate accounting of the number of deer taken from within the park is needed.

*Suggested Management Recommendations:*

- Continue to permit and encourage harvesting of white-tailed deer in NERI.
- Attempt to reduce deer densities to 8 deer/km<sup>2</sup> (20 deer/mi<sup>2</sup>) in forested areas of NERI.

Black Bear:

*Current Status and Significance:* Biologists estimate that there are over 10,000 black bears in West Virginia (WV DNR 2003) but the number of black bears within NERI is unknown. In 2002, hunters harvested a record 1,357 bears in West Virginia, reflecting a growing population of bears within the state. The majority of the population increase is centered in the southern part of the state. In response to this rapidly growing bear population, the WV DNR initiated a southern bear study to look at reproduction in Raleigh, Fayette, Boone, and Kanawha counties (S. Pugh, 2003, NPS, pers. comm.). Although this study is ongoing, preliminary results indicate a very healthy bear population in this region with an average litter size of three cubs. WV DNR has expanded bear hunting opportunities throughout the state to keep pace with the biological and sociological carrying capacities for bears in each region. The WV DNR recently opened a statewide archery season, additional gun hunting, and a special November gun season in five southern counties, including Fayette and Raleigh, where bear numbers exceed management objectives.

*Threats:* Black bears throughout the Appalachians are threatened by poachers who illegally kill black bears in order to sell their gall bladders and paws on the international market (WV DNR 2003). Resource managers and law enforcement officials should continually monitor NERI to prevent black bear poaching in the park.

*Gaps in Knowledge:* The actual population size harvest numbers for black bear in NERI are unknown. A more accurate accounting of the number of bear taken from within the park is needed.

*Suggested Management Recommendations:*

- Continue to permit and encourage harvesting of black bears in NERI.

- Develop and implement a management plan to minimize bear/visitor conflicts (e.g., encourage campers to hang food, and install bear-proof waste containers).
- Determine population size of black bears in NERI.

#### Allegheny Woodrats:

*Current Status and Significance:* NERI contains stable, healthy, globally significant populations of Allegheny woodrats, which is a species of special concern in West Virginia and is in decline throughout the rest of its range in the eastern U.S. (Buhlmann and Vaughan 1987; Michael and Voytko 1990; Balcom and Yahner 1996) (Table 2). The woodrat populations in and around NERI may represent the core population for this species in the eastern U.S. (Wood 2001). Therefore, due to this species' decline throughout the eastern U.S., the woodrat populations at NERI are critical from a conservation perspective. The reasons for the decline of woodrats in other portions of its range are unclear (Balcom and Yahner 1996).

*Threats:* Decline in the population of Allegheny woodrats, as seen throughout the rest of its range, is possible in NERI. Increased forest fragmentation, habitat loss, and infection of roundworms transmitted by raccoons (*Procyon lotor*) have been suggested for the decline in Allegheny woodrats in other portions of its range (Balcom and Yahner 1996).

*Gaps in Knowledge:* The reason for the persistence of Allegheny woodrats within NERI is unknown. Their persistence in the park, compared to declines in the rest of their range, may be due to the occurrence of abandoned mine portals. However, a detailed comparison of the habitat used by woodrats in NERI compared to other portions of their range is needed.

#### *Suggested Management Recommendations:*

- Allegheny woodrat populations at NERI should be monitored carefully in order to detect any declines, should they occur.
- Habitat used by woodrats at NERI, including abandoned mine portals, caves, and shale slopes, should be mapped into GIS and protected from excessive visitor use and development (Weese 1990; 1991; Bryan et al. 1999; Wood 2001).
- Mine portals that are occupied by woodrats should remain open. These openings seem to provide habitat needed for the woodrats; as Wood (2001) captured no woodrats at mine portals that had been completely closed by backfilling even when mitigation pipes were present.

#### Bat Communities:

*Current Status and Significance:* NERI contains a regionally significant assemblage of bats that includes 10 species that have been documented through various methods of study (Buhlmann and Vaughan 1987; WV DOT 1999; Johnson 2003). Two federally endangered species of bats (Virginia big-eared bat and Indiana bat) have been identified as using abandoned mine portals at NERI (S. Castleberry, 2003, University of Georgia, pers. comm.; Johnson 2003). In addition, two state-rare species of bats, eastern big-eared bat (*Corynorhinus rafinesquii*) and small-footed myotis (*Myotis leibii*), also have been identified using abandoned mine portals in the park (S. Castleberry, 2003, University of Georgia, pers. comm.) (Table 2). Bryan et al. (1999) did not capture any of these species of special concern using traditional mist-netting techniques. Furthermore, WV DOT did not capture Indiana bat in a targeted study for this species. However,

they did capture small-footed myotis, big brown bat (*Eptesicus fuscus*), eastern pipistrelle (*Pipistrellis subflavus*), and silver haired bat (*Lasionycteris noctivigans*) along the proposed alignment of the New River Parkway (I-64). Bats at NERI use abandoned mine portals as roosting sites and cliffs for foraging (Johnson 2003). Ongoing research by Wood et al. (2002) and Castleberry et al. (2002) is examining what species of bats use mine portals in NERI and where these species forage.

*Threats:* Excessive visitor use of mine portals may disturb bats that use the portals for roosting or hibernation.

*Gaps in Knowledge:* Despite preliminary studies, relatively little is known about the bats that are found in the park. For example, information about foraging behavior, diet, and habitat use is needed for all species.

*Suggested Management Recommendations:*

- Mine portals used by rare bat species should be identified and mapped.
- Mine portals should be protected from excessive visitor use by controlling access through use of proper gating techniques. Proper protection of mine portals will assure accessibility by bats and other species of wildlife (Weese 1990).
- Because bats may forage along cliff faces, the potential impacts of recreational rock climbing on bat communities should be explored.

*Small Mammals:*

*Current Status and Significance:* Buhlmann and Vaughan (1987) trapped 10 species of small mammals (mice, voles, shrews, and moles) within NERI. The long-tailed shrew (*Sorex dispar*), southern pygmy shrew (*S. hoyi winnemana*), and golden mouse (*Ochrotomys nuttalli*) are small mammals of special concern that have been documented at NERI (McDonald and Harmon 1989; WV DNR 2003) (Table 2). Other rare species of small mammals such as rock vole (*Microtus chrotorrhinus*), rock shrew (*S. dispar*), and water shrew (*S. palustris*) all may occur at NERI as suitable habitat seems to be available. Although research should be conducted to determine if these species occur at NERI, they are difficult to capture and confirmation of their occurrence may be time and labor intensive.

*Threats:* If the water shrew occurs at NERI, loss of eastern hemlock due to infestation by the hemlock woolly adelgid may negatively affect this species.

*Gaps in Knowledge:* The distribution and/or occurrence of several small mammals is unknown in the park.

*Suggested Management Recommendations:*

- Conduct a park-wide survey for small mammals to determine which species are found in NERI.
- Determine habitat use by small mammals in NERI.

#### Fur-bearing and Other Mammals:

*Current Status and Significance:* Bulmann and Vaughan (1987) documented beaver (*Castor canadensis*), mink (*Mustela vison*), and muskrat (*Ondatra zibethicus*) in NERI, and recently, river otter (*Lutra canadensis*) have been introduced into the New River system (Purvis et al. 2002).

*Threats:* Poor water quality in tributaries and the main stem of the New River could negatively affect populations of riparian, fur-bearing mammals.

*Gaps in Knowledge:* Little is known about the occurrence, distribution, and status of the federally endangered northern flying squirrel (*Glaucomys volans fuscus*), which is predicted to occur but never documented at NERI (WV Gap Analysis Program 2003). In addition, there is a paucity of information about the distribution and density of populations of riparian and furbearing mammals such as northern river otter, beaver, mink and other weasels, muskrat and bobcat (*Felis rufus*) in the park.

#### *Suggested Management Recommendations:*

- Prevent further degradation and improve water quality in tributaries and in the main stem of the New River.
- Conduct a park-wide survey for fur-bearing mammals to determine which species are found in NERI.
- Determine habitat use by fur-bearing mammals in NERI.
- Conduct a park-wide survey for northern flying squirrels by establishing nest boxes in suitable (coniferous) habitat.

#### Bird Communities

Currently, 233 species of birds are known to occur in NERI (NPSpecies 2003). This represents 74.4% (125 of 168 species) of the species found in West Virginia and 42% (25 of 59 species) of the species identified as state species of special concern (WV Gap Analysis Program, 2003). Of the 233 species found in NERI, approximately 93 were detected during breeding season and, therefore, may nest in the park (Pauley et al. 1997). Current research at NERI includes point-count surveys for birds at two deciduous forest stands (Shaw 2002), Monitoring for Avian Productivity and Survivorship (MAPS; Canterbury et al. 2002), fall migration bird-banding stations at Sandstone Falls (Canterbury and Stover 1998), and point-count surveys in hemlock stands (Wood 2000). The avian communities of NERI also have been studied at proposed development sites (Pauley 1993; Pauley et al. 1997), Kates Branch Wetland (Eye 1981), along transmission right-of-way corridors (Michael and Voytko 1990), and various locations throughout the park during the 1980s (Buhlmann and Vaughan 1987). No surveys have been conducted for nocturnal birds found in NERI.

#### Neotropical Migratory Birds:

*Current Status and Significance:* NERI is globally significant in providing critical habitat for neotropical migratory birds (neotropical migrants), especially the wood warblers (Family Parulidae). These species depend upon unfragmented mixed-deciduous forests with well-developed canopies and gap dynamics (e.g., tree falls) in place. Cerulean warblers, a species of

neotropical migrant that is in decline throughout the Northeast and is a candidate for federal listing, appear to have a concentrated distribution in and around NERI (Rosenberg et al. 2000). This population of cerulean warblers may be a critical source population for the Appalachians (Rosenberg et al. 2000). Several other species of neotropical wood warblers found at NERI, including Swainson's warbler (*Limnothlypis swainsonii*), wood thrush (*Hylocichla mustelina*), Kentucky warbler (*Oporornis formosus*), and worm-eating warbler (*Helmitheros vermivorus*), are either species of special concern in West Virginia (Swainson's warbler) or are on the Partners in Flight (PIF) watchlist (wood thrush, Kentucky warbler, worm-eating warbler) (USFWS 1999). The PIF watchlist does not include federally threatened or endangered species; rather, it identifies those species that are still fairly common but which will probably someday become threatened or endangered (USFWS 1999). Several species on the watchlist have declined precipitously over the past several decades, occupy habitats that are under severe threat, are found in low numbers, or have such restricted ranges that their existence is tenuous (USFWS 1999).

Aside from the species dependent upon mature, unfragmented forests, some bird species depend upon small (<1 ha [2.47 ac]) forest gaps created by tree falls and other natural and/or human induced disturbances (e.g., logging, land clearing around abandoned mine sites). These forest gaps contain early successional vegetation communities and add vegetative and structural diversity to the forest landscape. The golden-winged warbler (*Vermivora chrysoptera*), a species of special concern in West Virginia and declining throughout the eastern U.S., is a species that depends on these gap dynamics and is currently found in NERI (Pauley 1993; Pauley et al. 1997; Canterbury et al. 2002).

Hemlock stands provide another important habitat component for rare species of birds at NERI (Wood 2000). The Swainson's warbler and Louisiana waterthrush (*Seiurus motacilla*), two species that are either species of special concern or listed on the PIF watchlist in West Virginia, nest along streams in forests with some hemlock and/or rhododendron component (Wood 2000; O'Connell et al. 2003).

*Threats:* Populations of neotropical wood warblers are threatened by loss of forest habitat and forest fragmentation, particularly along waterways and in upland forests. For example, Buhlmann and Vaughan (1987) found that wood warblers were absent from two developed sites within NERI, indicating that development and other forms of forest fragmentation could threaten these species. Hemlock-dependent species will be adversely threatened if hemlock woolly adelgid causes hemlock decline in the park.

*Gaps in Knowledge:* Despite ongoing studies, more research is needed to better understand avian habitat relationships, avian distribution and abundance, and avian reproductive success at NERI.

*Suggested Management Recommendations:*

- Determine habitat relationships, distribution and abundance, and reproductive success for cerulean, Swainson's, Kentucky, worm-eating, and golden-winged warblers in NERI.
- Minimize fragmenting influences on forest blocks in NERI.
- Maintain and/or encourage natural gap dynamics in the forests of NERI in order to support populations of golden-winged warblers in the park.

#### Waterbirds and Waterfowl:

*Current Status and Significance:* The waterways of NERI support species of birds that depend on good water quality (e.g., Louisiana water thrush, belted kingfisher [*Ceryle alcyon*]). Water-dependent species found in NERI, such as green herons (*Butorides virescens*), great blue herons (*Ardea herodias*), spotted sandpipers (*Actitis macularia*), and various species of waterfowl, use riparian corridors along tributaries and emergent weed beds for foraging habitat (Buhlmann and Vaughan 1987).

*Threats:* Poor water quality threatens populations of aquatic-dependent avian species in NERI.

*Gaps in Knowledge:* Little is known about the effects of water quality, especially along polluted tributaries, on the aquatic-dependent avian communities of NERI.

#### *Suggested Management Recommendations:*

- Prevent further degradation and improve water quality in tributaries and in the main stem of the New River.
- Conduct riparian surveys for herons, sandpipers, waterfowl, and kingfishers in the park.

#### Raptors:

*Current Status and Significance:* Buhlmann and Vaughan (1987) and Pauley et al. (1997) documented 13 species of raptors in NERI. Peregrine falcons (*Falco peregrinus*), once a federally listed species and since delisted, have been sighted in the gorge and could potentially nest on the cliff faces at NERI (Sullivan 1995). Peregrine falcons have been hacked in NERI, but no current or historical nesting records for the park exist (Sullivan 1995; Jarvis 2002). Ongoing efforts to determine if peregrines are nesting in the park include “Cliff Watch,” a cooperative effort between NERI, WV DNR, and volunteers. Cliff Watch volunteers conduct field surveys for peregrines during the first week in April (Sullivan 1995). In addition to the peregrine, another rare raptor, the bald eagle (*Haliaeetus leucocephalus*), has been documented in the park (NPSpecies 2003).

*Threats:* Raptors are particularly susceptible to West Nile virus, but this pathogen has the potential to negatively affect various bird species in NERI. Rock-climbing may disturb any peregrines that attempt to nest in NERI.

*Gaps in Knowledge:* Until recently, a complete raptor survey has not been conducted for NERI. In 2003, however, a raptor survey for the park was funded (R. Watts, 2003, College of William and Mary, Williamsburg, VA).

#### *Suggested Management Recommendations:*

- Determine distribution, abundance, and reproductive success of raptors that breed in the park.
- If peregrines are found attempting to breed in the park, limit visitor access to nesting sites for the duration of the breeding season.

#### Wild Turkey:

*Current Status and Significance:* Based on harvest records, wild turkey populations in West Virginia appear to be stable or expanding (WV DNR 2003). Biologists estimate that there are

approximately 130,000 turkeys found in West Virginia (WV DNR 2003). The last decade has ranked as the most productive turkey harvest period on record in West Virginia. In 2002, there were 19 turkeys harvested from NERI (WV DNR 2003). Hunters may have harvested many more turkeys within NERI but failed to indicate locations on harvest records.

*Threats:* None known at this time.

*Gaps in Knowledge:* A more accurate accounting of the number of turkeys found within and harvested from the park is needed.

*Suggested Management Recommendations:*

- Continue to permit harvesting of wild turkeys in NERI.
- Determine population size and quantity of wild turkeys harvested in NERI.

## Reptiles

Thirty-eight species of reptiles have been documented in NERI (NPSpecies 2003), and this community is further described by Pauley et al. (1997). Based on data from the West Virginia Gap Analysis Program (WV GAP) (2003), approximately 79.5% (31 of 39 species) of the reptiles of West Virginia are predicted to occur in NERI and 62% (10 of 16) of the reptile species of special concern are predicted to occur in the park (Table 2).

Turtles:

*Current Status and Significance:* Five species of turtles are found in NERI (Seidel 1981; Green and Pauley 1987). Within NERI, two subspecies of the painted turtles (*Chrysemys picta marginata* and *C. p. picta*) are found and NERI is one of the few areas where these subspecies interbreed, making the park regionally significant for painted turtles (Buhlmann and Vaughan 1987). Research conducted on the eastern river cooter (*Chrysemys concinna*), a species of special concern in West Virginia, confirmed that this is a native turtle in NERI (Buhlmann and Vaughan 1987, Table 2). One other turtle species of special concern, the common map turtle (*Graptemys geographica*), is known from NERI (Table 2).

*Threats:* Poor water quality in the tributaries and main stem of the New River may adversely affect turtle populations in NERI.

*Gaps in Knowledge:* Little is known about distribution and use of the New River by turtles, especially those in the family Emydidae.

*Suggested Management Recommendations:*

- Prevent further degradation and improve water quality in the tributaries and main stem of the New River.
- Determine distribution and use of the New River by turtles in the family Emydidae.

Lizards and Snakes:

*Current Status and Significance:* Timber rattlesnakes (*Crotalus horridus*) are known from several locations at NERI including Stone Cliff, Glade Creek, and Grandview (J. Perez, 2004,

NPS, per. comm.). Buhlmann and Vaughan (1987) did not find timber rattlesnakes or the rare coal skink (*Eumeces anthracinus*) in their surveys of NERI although they did find large populations of fence lizards (*Sceloporus undulatus*), five-lined skinks (*Eumeces fasciatus*), and copperheads (*Agkistrodon contortrix*). Three other reptile species of special concern, the broad-headed skink (*Eumeces laticeps*), eastern worm snake (*Carphophis amoenus*), and rough green snake (*Opheodrys aestivus*) are known from NERI (Table 2) (NPSpecies 2003).

*Threats:* Unknown.

*Gaps in Knowledge:* There are almost no data for lizards and snakes within NERI, although rock outcrops and cliff faces in the park provide potential habitat for these reptiles. Babcock State Park, which lies within the authorized boundary of NERI, contains den sites of timber rattlesnakes.

*Suggested Management Recommendations:*

- Conduct a park-wide survey for lizards and snakes.
- If den sites for rattlesnakes are located their location should be mapped so that they can be protected from development and visitor use.

## Amphibians

Continuous forest, abandoned mine portals, and river/stream systems of NERI provide habitat for a diverse, nationally significant assemblage of amphibians. NPSpecies (2003) contains records for 48 species of amphibians known from NERI. These species represent 82% (37 of 45 species) of the amphibian species known from West Virginia and 60% (10 of 17 species) of the state species of special concern (WV Gap Analysis Program 2003).

*Salamanders:*

*Current Status and Significance:* Pauley et al. (1997) found that NERI contained a diversity of woodland salamanders, an outstanding natural value that is characteristic of the Appalachians. In fact, the southern Appalachians contain the most diverse temperate salamander communities in the world (Southern Appalachian Biodiversity Institute 2003).

The eastern hellbender (*Cryptobranchus alleganiensis*), a species of special concern in West Virginia, may occur within NERI though it has never been documented. Buhlmann and Vaughan (1987) conducted intensive searches for this species in the park and found none. The mudpuppy (*Necturus maculosus*), another large aquatic salamander, was captured by Buhlmann and Vaughan (1987) in NERI.

The black-bellied salamander (*Desmognathus quadramaculatus*), a species of special concern in West Virginia, is at the northern most portion of its range in NERI (McDonald and Harmon 1989). This species is used as popular fishing bait and may be susceptible to over-collecting. Nielsen and Orth (1988) indicated that over 50% of all commercial bait licensees handled salamanders. Despite this consumptive use of the salamander recent research indicates that the black-bellied salamander is more common than previously thought in the park (Pauley et al. 1997; Purvis et al. 2002).

Cave salamanders, another species of special concern in West Virginia, use abandoned coal mines at NERI (Pauley et al. 1997; Bryan et al. 1999). Cave salamanders use other habitat (e.g., fractured rock) in the park, but mine portals allowed researchers to easily find the salamander and confirm its presence in the park.

Wet sandstone cliffs are critical habitat for the rare green salamander (*Aneides aeneus*) and the common slimy salamander (*Plethodon glutinosus*) (Buhlmann and Vaughan 1987; Pauley 1993; Pauley et al. 1997). Tributaries of the New River contain a high species richness of salamanders within the park (Buhlmann and Vaughan 1987). Dowdy Creek appears to be an especially important, high-quality stream supporting both black-bellied and spring salamanders (*Gyrinophilus porphyriticus*) (Buhlmann and Vaughan 1987).

Jefferson salamanders (*Ambystoma jeffersonianum*) and Cumberland plateau salamanders (*Plethodon kentucki*), both species of special concern in West Virginia, are found in NERI (Pauley et al. 1997). The cheat mountain salamander (*Plethodon nettingi*), a federally listed threatened species, is predicted to occur in NERI by WV GAP (2003); however, it has not been documented within the park and the appropriate habitat (boreal forests) is not available in the park.

*Threats:* Poor water quality in the tributaries and main stem of the New River threatens salamander populations in the park. In addition, over-collecting of salamanders by anglers and commercial bait harvesters may threaten salamander populations in NERI. Invasive, nonnative plants in wetlands and riparian areas may adversely affect breeding habitats for salamanders.

*Gaps in Knowledge:* Little is known about the occurrence and distribution of ephemeral pools and other small wetlands in the park and their use by salamanders. More research is needed to ascertain the use of the New River and its tributaries by salamanders, especially by the eastern hellbender and other stream salamanders. In addition, the extent of use of abandoned mine portals by salamanders should be determined.

*Suggested Management Recommendations:*

- All abandoned mine portals used by salamanders, especially those of special concern, should be mapped and protected from visitor use.
- Wetlands should be mapped and their use by salamanders determined.
- Water quality in the New River and its tributaries should be improved and not further degraded.
- Surveys for stream salamanders, especially for the eastern hellbender, should be continued in the park.

*Frogs and Toads:*

*Current Status and Significance:* Little is known about the distribution and abundance of frogs and toads in NERI. They potentially are an important food resource for herons and riparian mammals.

*Threats:* Nonnative frogs such as the green treefrog (*Hyla cinerea*) and squirrel treefrog (*Hyla squirella*) may be being inadvertently introduced to NERI from motor homes and deserve further study.

*Gaps in Knowledge:* Little is known about the distribution and abundance of frogs and toads in NERI.

*Suggested Management Recommendations:*

- Wetlands should be mapped and their use by frogs and toads determined.
- Water quality in the New River and its tributaries should be improved and not further degraded.
- Park-wide surveys for frogs and toads should be conducted.

## Fish

Compared to other groups of vertebrates, there has been quite a bit of research on the fish of NERI. For example, Addair (1944) and Stauffer et al. (1980) conducted general aquatic biological surveys of the New River in West Virginia and Virginia. Purvis et al. (2002) provided a complete list of all fish species known from NERI and their status within the park (e.g., native, nonnative, rare, common, etc.). Despite continued research, there does seem to be some discrepancy as to the exact number of fish taxa found in NERI. For example, NPSpecies (2003) lists 72 species of fish from NERI, but Purvis et al. (2002) indicates that 90 species of fish are known from the entire New River watershed. Based on WV GAP data, which predicts 68 species of fish to occur in NERI, the fish species found in the park represent 40% (68 of 167 species) of the fish species known from West Virginia and 10% (7 of 68 species) of the species of special concern from West Virginia (WV Gap Analysis Program 2003).

A variety of habitat types within the New River, including runs, riffles, pools, pool edges, and environments created by submerged snags, support a diversity of fish. The most common species within the New River are bigmouth chub (*Nocomis platyrhynchus*), spotfin shiner (*Cyprinella spiloptera*), silver shiner (*Notropis photogenis*), mimic shiner (*Notropis volucellus*), bluntnose minnow (*Pimephales notatus*), channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictis livaris*), and smallmouth bass (Lobb and Orth 1987, Purvis et al. 2002). Small tributaries contain brook trout (*Salvelinus fontinalis*), rosyside dace (*Clinostomus funduloides*), blacknose dace (*Rhinichthys atratulus*), creek chub (*Semotilus atromaculatus*), mottled sculpin (*Cottus bairdii*), and fantail darter (*Etheostoma flabellare*).

Five guild assemblages of fish (segregated by habitat) are present in the New River within NERI (Lobb and Orth 1987). These fish guilds (edge-pool guild, habitat-generalists guild, pool guild, edge-channel guild, and run guild) seem to segregate due to the differences in predation risk and food availability among habitat types. In general, velocity and vegetation were most strongly correlated with fish densities; therefore, changes in these variables due to daily flow fluctuations associated with potential hydropower generation at Bluestone Dam may negatively affect fish densities within certain guilds in the New River (Lobb and Orth 1987).

#### Native Nongame Fish:

*Current Status and Significance:* The New River drainage has a native fish fauna that is distinct from those of the rest of the Ohio River system (Jenkins and Burkhead 1994). The fauna are composed of relatively few native species with a high proportion of these species being endemic (Lincoln et al. 1982). The high rate of endemism is primarily due to the isolation of the New River from neighboring river systems by Kanawha Falls (Sheldon 1988). Seven species of fish are endemic to the New River drainage (Stauffer et al. 1980; Jenkins and Burkhead 1994): bigmouth chub, New River shiner (*Notropis scabriceps*), Kanawha minnow (*Phenacobius teretulus*), fine-scaled saddle (candy) darter (*Etheostoma osburni*), Bluestone sculpin (*Cottus* sp.[undescribed]), Kanawha darter (*Etheostoma kanawhae*), and Appalachian darter (*Percina gymnocephala*). However, only the bigmouth chub, a species of special concern in West Virginia, and the New River shiner have been collected within the boundaries of NERI (Stauffer et al. 1980; Welsh and Wellman 2001; J. Purvis, 2004, NPS, pers. comm.) (Table 2).

The bigmouth chub spawns in mid-May in riffle, run, and tail-of-pool habitats (Lobb and Orth 1988). Areas with gravel (used for nest building), shallow depths, and moderate velocities are preferred spawning habitat for this species (Lobb and Orth 1988).

*Threats:* Waterflow changes may negatively affect spawning habitat for the bigmouth chub. For example, minimum waterflow must maintain sufficient depths over spawning areas to prevent dewatering, but not be too high so as to erode gravel nest mounds, especially during peak spawning activity (Lobb and Orth 1988). Poor water quality in the tributaries and main stem of the New River threatens fish populations. Nonnative fish threaten native fish assemblages through competition for habitat and food.

*Gaps in Knowledge:* The effects of nonnative fish on native fish needs to be better understood in the park. The effects of waterflow regulation on native fish needs to be better understood.

#### *Suggested Management Recommendations:*

- Water quality in the park should be improved and not further degraded.
- Continue to monitor the park to determine the abundance and distributions of both native and nonnative fish.
- Determine the effects of nonnative fish and waterflow regulation on the native fish of NERI.
- Discourage further introductions of nonnative fish to NERI.

#### Nonnative Fish:

*Current Status and Significance:* The New River watershed has an unusually high number of nonnative fish. Forty-seven species of fish in the New River watershed are native and 43 are nonnative (Purvis et al. 2002). With 48% of its fish fauna being nonnative, the New River system has the largest number and proportion of nonnative fish species among major eastern and central North American drainages (Jenkins and Burkhead 1994; Mott 1995). Prior to European settlement, Kanawha Falls acted as a natural barrier to fish migration, and the portion of the New River above the falls was relatively depauperate in fish diversity but had a high rate of endemism (Jenkins and Burkhead 1994). Today, as a result of nonnative species introductions, species distribution above and below the falls is about equal (Cincotta et al. 1999). Recent research indicates that several species of nonnative fish have expanded their range in the park (Cincotta et

al. 1999). The most recent addition to the New River fauna is the rudd (*Scardinius erythrophthalmus*), a minnow native to Europe (Easton et al. 1991).

One factor that appears particularly important in the introduction and the spread of nonnative fish species in NERI is the dumping of bait buckets by anglers (Purvis et al. 2002). In particular, least brook lamprey, telescope shiner, whitetail shiner, spottail shiner, and variegated darter are probably benefiting from bait bucket dumping (Purvis et al. 2002). The introduction of nonnative fish and their range expansions within the New River could have negative effects on native fish populations. For example, the variegated darter and rainbow darter (*Etheostoma caeruleum*) are nonnatives that may out compete natives (Welsh and Wellman 2001).

*Threats:* None.

*Gaps in Knowledge:* The rate of continued nonnative fish introductions and their effects on native fish are unknown.

*Suggested Management Recommendations:*

- The abundance, distribution, and range expansion of all nonnative fish should continue to be monitored in NERI.
- The introduction of nonnative fish should be discouraged.

*Game Fish:*

*Current Status and Significance:* The New River within NERI is one of the most important warm-water fisheries in West Virginia and is one of the most heavily fished areas in the eastern U.S. (Purvis et al. 2002; Jones and Purvis 2003). The New River contains excellent warm-water fish habitat, with a pool-riffle geomorphic structure, abundant cover, and generally good chemical quality. New River game fish include muskellunge, channel and flathead catfish, white crappie (*Pomoxis annularis*), black crappie (*Pomoxis nigromaculatus*), smallmouth bass, spotted bass (*Micropterus punctulatus*), largemouth bass, and walleye (*Sander vitreum*) (National Park Service 1994). Most game fish presently found in the New River were deliberately introduced, and only four game fish, American eel (*Anguilla rostrata*), channel and flathead catfish, and green sunfish (*Lepomis cyanellus*), are native (Jenkins and Burkhead 1994). In addition, the state of West Virginia stocks nonnative rainbow and brown trout in the tributaries to the New River within NERI (Mott 1995).

One of the most sought after game fish in the New River is smallmouth bass. This game fish is not native to the New River or its drainages and was probably first introduced in West Virginia in the early 1800s (Jenkins and Burkhead 1994). This species supports a valuable recreational fishery throughout its native and introduced range. Smallmouth bass decrease in abundance downstream of Bluestone Dam, correlating with a decrease in macroinvertebrate production downstream from the dam (Easton et al. 1995). Larval smallmouth bass feed primarily on microcrustaceans, whereas larger young smallmouth bass switch their prey preference to aquatic and larval insects, primarily Ephemeroptera (mayfly) nymphs (Easton et al. 1995). Large smallmouth bass (>304 mm [>12 in]) feed primarily on fish and crayfish. New River smallmouth bass spawn between late April and mid-July (Graham and Orth 1986), and timing of spawning is triggered by temperature. High flow in the New River caused by dam discharges or

natural flooding events could interrupt smallmouth bass spawning activity and decrease foraging success, especially during early summer (Graham and Orth 1986; Easton et al. 1995). In order to protect this important recreational resource, catch-and-release for smallmouth and largemouth bass is in effect in NERI between I-64 and the takeout at Grandview sandbar (J. Purvis, 2003, NPS, pers. comm.).

*Threats:* Over-harvesting of game fish is a potential threat to these populations in NERI. Poor water quality in the New River and its tributaries threatens game fish populations.

*Gaps in Knowledge:* Little is known about the impacts of state fishing regulations, including deliberate stocking, on game fish in the New River.

*Suggested Management Recommendations:*

- Determine how state fishing regulations affect game fish in the New River (e.g., is catch and release increasing populations of smallmouth bass in the New River?).
- Continue to monitor game fish abundance, distribution, and reproductive success in NERI.
- Determine how nonnative game fish affect native fish species in NERI.
- Water quality in the New River and its tributaries should be improved and not further degraded.

Aquatic Invertebrates

Molluscs, crayfish, and other macroinvertebrates are important components of aquatic environments in the park. Almost nothing is known about aquatic gastropods and cave crustaceans found in NERI. However, at least five species of pulmonate snails are found in the New River (Dillon and Benfield 1982) and abandoned mine portals in the park may provide significant habitat for cave isopods.

Mussels:

*Current Status and Significance:* The majority of mussel beds in NERI exist in the upper third of the park (Jirka and Neves 1987). Mussels decrease significantly in abundance below Glade Creek with no living or dead mussels found in the lower 12.8 km (eight mi) of river within NERI (Jirka and Neves 1987). Jirka and Neves (1987) identified eight species of mussels in NERI that were predominately found on gravel, cobble, and sometimes sandy substrate. In addition, submerged aquatic vegetation is important for the establishment of mussel beds in NERI. It is hypothesized that these submerged aquatic vegetation provide habitat to the fish hosts of the larval mussels (Jirka and Neves 1987). Additionally, the environmental conditions created by islands in the New River seem to support mussel beds (Jirka and Neves 1987).

Pennington and Associates (2002) found only five species of mussels in their study area within NERI. Pennington and Associates (2002) did not find any of the uncommon mussels (e.g. pocketbook mussel [*L. ovata*], wavy-rayed lampmussel [*L. fasciola*], or elktoe mussel [*Alasmidonta marginata*]) found by Jirka and Neves (1987). Whether this is due to their limited study area or loss of these taxa from NERI is unknown. However, Pennington and Associates (2002) did detect mapleleaf mussel (*Quadrula quadrula*) in the park, a species of mussel not collected by Jirka and Neves in 1987.

Mucket pearly mussel (*Actinonaias [ligamentina] carinata*) is the most common mussel species within NERI although this species has never been collected in the New River upstream of Roundbottom Creek (Markham et al. 1980; Pennington and Associates 2002). Two species of mussels, pistolgrip mussel (*T. verrucosa*) and pocketbook mussel, may have been more common in the river in the recent past (Jirka and Neves 1987). Pennington and Associates (2002) found relic shells of the pistolgrip mussel in NERI but no living specimens.

Although NERI supports abundant mussel fauna, it is relatively low in diversity (Jirka and Neves 1987). The relatively low diversity of mussel fauna within NERI (eight or nine species) is notable when compared with the diversity of mussels (34 species) found in the Kanawha River (Taylor 1983). Physical barriers to upstream dispersal of fish and mussels, particularly Kanawha Falls, have probably the greatest influence on mussel diversity in the park (Jirka and Neves 1987).

The native mussel communities of the New River constitute an important part of the benthic community of NERI and steps should be taken to protect this valuable resource. Because native mussels are declining throughout the Appalachians, and because of their dependence on good water quality, most native mussels are recognized as species of special concern in West Virginia (Table 2).

*Threats:* Runoff, a result of the construction of I-64, and periodic low summer flows, have caused mortality of mussels within NERI (Jirka and Neves 1987). In addition, habitat alterations associated with potential hydroelectric power generation threaten mussel diversity. In particular, changes in substrate type and stability (e.g., erosive discharges), and high silt loads associated with dam discharges and sedimentation may negatively affect mussel communities (Jirka and Neves 1987). Poor water quality in the New River also threatens native mussel communities in NERI.

The native mussel community also may be at risk from competition with nonnative species. The introduced Asian clam (*Corbicula fluminea*) is well established throughout the New River (Stauffer et al. 1980). Unlike native mussels, *Corbicula* have free-swimming larvae (Pennak 1989) and, therefore, do not require a specific fish host to complete their life cycle.

*Gaps in Knowledge:* A very invasive, nonnative mollusc, the zebra mussel (*Dreissena polymorpha*), has not been detected in NERI (U.S. Geological Survey [USGS] 2003), but the park should monitor for its presence.

*Suggested Management Recommendations:*

- The native mussel fauna found in NERI deserves further study to better understand their abundance, diversity, and distribution in the park.
- Water quality in the New River should be improved and not further degraded.
- Continue to monitor for zebra mussels and other nonnative mussels in the park and prevent their introduction.

#### Crayfish:

*Current Status and Significance:* Seven species of crayfish have been described from NERI (Roell and Orth 1985; NPS 1994): Sanborn's crayfish (*Orconectes sanbornii*), northern crayfish (*O. virilis*), Tennessee River spiny crayfish (*O. spinosus*), Allegheny crayfish (*O. obscurus*), Appalachian brook crayfish (*Cambarus bartonii*), rock crayfish (*C. carinirostris*), and Teays River crayfish (*C. sciotnensis*) (Markham et al. 1980; Jezerinak et al. 1995). The two species of *Cambarus* are considered native. Although the New River crayfish (*C. chasmodactylus*) has not been collected within NERI, it is listed as a species of special concern in West Virginia and should be searched for within the park. This species has only been collected in the Greenbrier watershed of the New River. All species of *Orconectes* were likely introduced by anglers as discarded or escaped bait (Purvis et al. 2002). By 1979, *O. virilis* comprised 90% of the crayfish collected at five seine sites between Bluestone Dam and Sandstone Falls (Markham et al. 1980).

Crayfish are an important food item for many birds, mammals, and reptiles and are the major food item for large smallmouth bass (Roell and Orth 1985). Crayfish also support an important recreational and commercial bait fishery in NERI (Nielsen and Orth 1988; Jones and Purvis 2003). At current levels, the commercial harvest seems to be sustainable in NERI with annual harvest by anglers and commercial bait catchers at about 4% of annual production (Roell and Orth 1985). By comparison, smallmouth bass consumed 23% of the annual production, with rock bass (*Ambloplites rupestris*) consuming 21% of annual production.

*Threats:* Competition with nonnative crayfish is a major factor contributing to 50% of U.S. and Canada crayfish being in need of conservation recognition. Increases in the current harvest rates for crayfish in NERI may threaten their population stability in the park. In addition, poor water quality in the New River and its tributaries may negatively affect crayfish populations in NERI.

*Gaps in Knowledge:* Little is known about the abundance and distribution of the native crayfish populations in NERI.

#### *Suggested Management Recommendations:*

- Continue research (Jones and Purvis 2003) that may help elucidate the abundance and distribution of the New River's crayfish populations.
- Periodic surveys of commercially licensed bait retailers and anglers should be conducted to assess the magnitude of the annual harvest of both native and nonnative species of crayfish.

#### Macroinvertebrates:

*Current Status and Significance:* A Long Term Ecological Monitoring System (LTEMS) for macroinvertebrates was established at NERI in 1988 and currently includes four monitoring sites: Bluestone Dam, Sandstone Falls, Prince, and Thurmond (Voshell et al. 1996). LTEMS data indicate that aquatic macroinvertebrates are most abundant at Bluestone Dam, but the macroinvertebrate community at Sandstone Falls is the most diverse. Overall, aquatic invertebrate abundance is highest directly below Bluestone Dam and decreases downstream (Voshell 1985).

Pauley et al. (1997) collected, identified, and analyzed aquatic macroinvertebrates from Fayetteville, Prince, Thurmond, Meadow, and Hinton quadrangles of NERI. Macroinvertebrate

data collected at 15 sites within these quadrangles indicated significant pollution impacts to streams. A study of macroinvertebrates in headwater streams of NERI found that both upper and lower reaches of Rush Run were significantly impaired due to poor water quality (Marshall 2001). In general, upper reaches of headwater streams in NERI have lower taxa richness, fewer EPT (Ephemeroptera, Plecoptera, Trichoptera) taxa, and lower biotic indices than lower reaches (Marshall 2001).

Hellgrammites (*Megaloptera* sp.) are relatively large aquatic macroinvertebrates that provide food for game fish and bait for anglers, and support a recreational and commercial bait fishery in and around NERI (Nielsen and Orth 1988; Roell and Orth 1985). Roell and Orth (1985) determined that 8% of the annual production of age 1 and 2 hellgrammites is harvested by anglers and commercial bait dealers. By comparison, rock bass consumed about 13% of this production, and smallmouth bass and flathead catfish together consumed less than 2%. Any increase in hellgrammite harvest by anglers and commercial bait dealers could potentially be detrimental to fish in NERI, especially to rock bass.

*Threats:* Poor water quality in the tributaries and main stem of the New River threaten populations of macroinvertebrates in NERI. In addition, the macroinvertebrate community in NERI may be negatively affected by severe flood events (Lobb and Orth 1987). In NERI, macroinvertebrates are found in stream sediments and clinging to macrophytes. Increases in natural or human-induced (e.g., dam releases) flood events could result in increased streambed and bank instability, streambed scouring, erosion, and turbidity, which discourages riparian vegetation, streambed vegetation, and algal growth (Lobb and Orth 1987). Any reduction in macrophytes and the dislodging of clinging macroinvertebrates would reduce the standing stock of macroinvertebrates in the New River and, potentially, have negative impacts on fish productivity (Lobb and Orth 1987). Furthermore, the application of the bacterial pesticide, *Bacillus thuringiensis* var. *israelensis* (*Bti*) to control black flies (*Simuliidae*) in the New River is a factor that may negatively affect macroinvertebrates

*Gaps in Knowledge:* The ability of the current LTEMs macroinvertebrate program at NERI to detect trends in population abundance and distribution of macroinvertebrates is unknown.

*Suggested Management Recommendations:*

- Evaluate the LTEMs program at NERI to determine if it can detect statistically significant trends in macroinvertebrate populations. Re-design program if necessary.
- Water quality at NERI should be improved and further degradation should be prevented.
- Conduct periodic surveys of commercially licensed bait retailers and anglers to assess the magnitude of the annual harvest of hellgrammites in NERI (Roell and Orth 1985).

*Black Fly Larva:*

*Current Status and Significance:* Black flies are found throughout the New River with the primary breeding area in the section between Hinton and Meadow Creek (Voshell 1984). The direct application of *Bti* by West Virginia to control black fly larva in the New River may detrimentally affect the availability of food for foraging fish, including smallmouth bass. For example, Voshell (1984) predicted that application of *Bti* would reduce the net productivity of caddisfly (*Trichoptera*) species and damselfly (*Odonata*) species and could reduce the

productivity of the hellgrammite population. However, several researchers could find no conclusive evidence that *Bti* application negatively affected macroinvertebrate production, macroinvertebrate community structure, fish growth and condition, or fish community structure (Voshell and Orth 1995). Smallmouth bass and other fish species may have adjusted their diet in light of black fly spraying because an earlier study indicated that, numerically, black flies were a significant component of the diet of fish in the New River (Hess 1983). In 1983, prior to commencement of black fly spraying, 24 of 26 fish species electroshocked in the New River below Bluestone Dam contained black flies in their stomachs (Hess 1983).

Smith and Marini (1998) examined several data sets (water chemistry, fish communities and populations, macroinvertebrates, and macrophytes) to determine if spraying of *Bti* to reduce black fly larvae altered the ecological community. They found no discernible effect on the ecological community other than its intended purpose (the reduction of black fly populations). They concluded that the ecological community within the New River is consistent with that of an impoundment river system and is primarily influenced by dam discharge.

*Threats:* Continued *Bti* application reduces black fly populations within NERI.

*Gaps in Knowledge:* The change in prey selection by smallmouth bass and other fish that feed on black fly larva is unknown.

*Suggested Management Recommendations:*

- Continue to monitor macroinvertebrates and fish communities to determine if spraying of *Bti* has a negative affect on the biota of the New River within the park.
- Examine prey selection of fish post-*Bti* application to determine how prey use has changed due to control of black fly larva in the New River.

Terrestrial Invertebrates

Very little is known about the terrestrial invertebrates of NERI. The particular habitats found in NERI, such as the abandoned mine portals and cliff faces, could support distinct assemblages of invertebrates. The abandoned mine portals at NERI provide a notable opportunity for insects as they may support diverse assemblages of rare insects, especially tiger beetles (*Cicindela* spp.).

*Insects:*

*Current Status and Significance:* NPSpecies (2003) only lists 67 taxa (genera, species, or families) of insects as being from the park. However, based upon WV GAP data, 85% (105 of 123 species) of the butterflies known from West Virginia are predicted to occur in NERI. Furthermore, 78% (21 of 27 species) of the state's butterfly species of special concern are predicted to occur in NERI (WV Gap Analysis Program 2003).

*Threats:* Unknown.

*Gaps in Knowledge:* Little to no research has been conducted on the insects found within NERI. Despite the predictions by the WV GAP data, no comprehensive inventory of butterflies or other terrestrial insect taxa have been conducted at NERI.

*Suggested Management Recommendations:*

- Conduct surveys for insects in the abandoned mine portals of NERI.
- Conduct park-wide but habitat-specific surveys for insects.

Terrestrial Gastropods:

*Current Status and Significance:* NPSpecies (2003) only contains one record of a gastropod from NERI.

*Threats:* Because of the presence of significant cliff environments at NERI, the potential for finding an exceptional assemblage of snails is high. Recreational use of cliff faces may threaten gastropod communities. For example, McMillan et al. (2003) found that snail density, richness, and diversity were lower along climbing routes than in unclimbed areas.

*Gaps in Knowledge:* Nothing is known about cliff-face snail communities at NERI. The cracks and crevices found in this habitat are potentially home to many species of snails. For instance, in Wisconsin, 25% of the state's land snails were found on a single cliff face (Nekola and Smith 1999).

*Suggested Management Recommendations:*

- Research should examine the distinctive ecosystem of the cliff environment, including looking at the invertebrates (including gastropods) that depend on this habitat type.